FEILDEN'S MAGAZINE

An

ENGINEERING REVIEW

Edited by C. EDGAR ALLEN.

Vol. 8. MAY, 1903. No. 5.

The Design of Flywheels.

By A. KEMP.

THE function of a flywheel is to store up energy during that portion of a revolution when the power generated is more than that required, and to give up this surplus energy when the demand for power exceeds the supply. To accomplish this, the flywheel must have a small fluctuation of speed, the amount of which depends on the nature of the work to be done

In the first place, it is of course necessary in the designing of a flywheel to keep the peripheral velocity within a safe limit, otherwise it may burst by centrifugal force,* and this limit for wheels with solid rims (this being by far the safest form) is at most 100 ft. per second in English practice, the usual rule, however, being 1 mile per minute, *i.e.*, 88 ft. per second. Built-up wheels, however, must run at a less velocity, usually about 50 ft. per second, but depending, of course, on the form of joint employed.

Now, f, the tension in the rim, is found by the equation

$$f = \frac{12\ w\ V^2}{g}.$$

For cast-iron, where $w = \cdot 26$ lb. per cubic inch and V is expressed in feet per second, we find that

$$f = \cdot 096\ V^2,$$

showing the low stress allowed in flywheel rims, being at most 960 lbs. per square inch.

Now, in order to find the weight of flywheel for any given case, we first obtain an Indicator Diagram, Fig. 1, which can be drawn from the data of the engine under consideration. An Indicator Diagram, however, only shows the pressure of the steam in the cylinder, and does not represent the pressure transmitted to the crank pin, because some of the power is absorbed in accelerating reciprocating parts, etc., during the first half of stroke, whilst during the second half the crank receives an excess of power over that supplied by the steam due to the momentum. The real power generated is that due to the difference of pressure between the two sides of the piston at any instant, therefore an effective steam pressure diagram can be plotted from the Indicator Diagram by taking the effective pressure (*i.e.*, the distance between the steam line of one diagram to the exhaust line of the other) at different portions of the stroke, and setting them out on a new base line, the positive portions above, and the negative portions below the line as in Fig. 2.

In the case of a vertical engine, the influence of the direct action of the weight of the moving parts should be allowed for in the last diagram, by adding or sub-

* See Prof. Benjamin's article on "Bursting of Flywheels" in FEILDEN'S MAGAZINE, vol. vii., p. 198.

FIG. 1.—INDICATOR DIAGRAM.

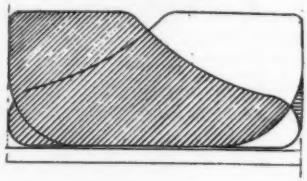


FIG. 2.—STEAM EFFORT DIAGRAM.

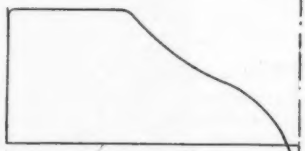
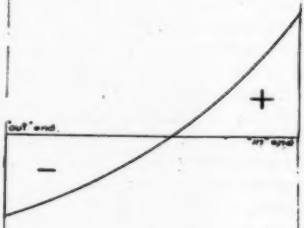


FIG. 3.—INERTIA DIAGRAM.



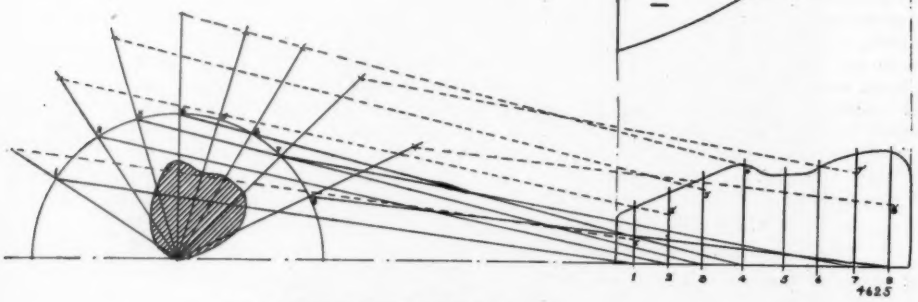


FIG. 4.—TWISTING MOMENT DIAGRAM.

NOTE.—Connecting-Rods 5 and 6 left out for clearness

tracting their weight (reduced to per sq. in. of piston area) according as it is making the downward or upward stroke.

Another diagram, Fig. 3, should then be made for inertia (or acceleration) by setting up a point above the base line at the "in" end of diagram equal in height to $\frac{w V^2}{g R}\left(1 + \frac{1}{N}\right)$ where w = weight of reciprocating parts, V = velocity of crank pin in feet per second, R = radius of crank-pin in feet, and $\frac{1}{N}$ = ratio of crank length to connecting-rod length, and for the "out" end of diagram, a line below the base line (therefore negative)= $\frac{w V^2}{g R}\left(1 - \frac{1}{N}\right)$. Both these values, however, must be reduced to feet per sq. in. of piston area, and both set out to the same pressure scale as the indicator diagram. The point of no inertia, namely, maximum velocity, takes place when the connecting-rod and crank are *nearly* at right angles, and therefore, by drawing a right-angled triangle with the length of connecting-rod for one side, and crank for the other, we get the length of the hypotenuse as the distance from the centre of shaft to the point of no inertia on the diagram, provided the diagram is taken to represent the travel of the piston, and a curve drawn through these three points gives the inertia diagram. If now a fourth diagram be drawn in which the negative and positive portions of the inertia diagram are subtracted from and added to the diagram of effective steam pressure respectively, and the resultant values plotted on a base line, we get the actual pressure transmitted to the crank pin at each instant, and the area of the new diagram should be equal to that of the original Indicator Diagram.

If the small end of the connecting rod be assumed to be the piston, then from numerous points such as 1, 2, 3, 4, etc., on the base line of this latter diagram can be drawn, the connecting rods terminating in the cranks in their various corresponding positions, 1, 2, 3, 4, etc.; and if the cranks be produced we can set off along them outside the crank-pin circle, the heights of the diagram at the corresponding positions of the piston. By then drawing lines from these points (shown dotted) parallel to the connecting rods, terminating in the vertical lines at 1′, 2″, 3′, 4′, etc., on the diagram, we get a series of new heights which may be set along the cranks proper from the centre of the shaft, and a curve drawn through these points gives a lobed figure which represents the twisting moment on the shaft for any position of the crank. For convenience, the twisting moment diagram last obtained must be plotted on a horizontal base line, Fig. 5, which should be made equal in length to the semi-circumference of the crank-pin circle, namely πR, and the area of this diagram should also be equal to that of the original indicator diagram. Now a line may be drawn representing the mean height of the diagram which will also be the line of resistance, provided this latter is constant, and that portion of the curve falling above this line, namely E, represents the surplus energy over that actually required; whilst the portions falling below,

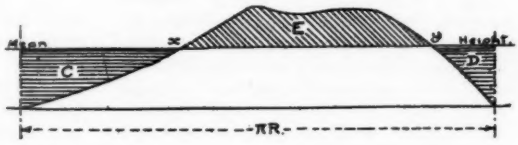


FIG. 5.

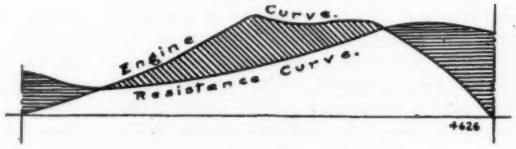


FIG. 6.

namely C and D, represent the deficit of energy, and the areas C and D together should be equal to the area E. It will thus be seen that the flywheel should be so designed that its capacity is sufficient to absorb (or give out) the *maximum* excess (or deficit) of energy, and this is determined by measuring the areas and selecting the largest of them. If the engine is a two-cylinder one with cranks at right angles, then two twisting moment diagrams must be plotted, the beginning of one being 90 degs. in advance of the other, and by adding the ordinates of the two curves, a third or resultant curve is obtained, and the mean height of this is equal to the mean resistance. It will be seen that by having several cranks, the amount of fluctuation is reduced, and consequently a lighter flywheel will suffice. It must also be noted that when the engine has more than one cylinder, the heights of the diagrams have to be corrected so that the mean height of each is proportional to the effort exerted on the piston.

The absorption of the excess energy tends to increase the velocity of rotation, the maximum in Fig. 5 being at y, and in like manner the delivering up of energy will cause a decrease, being a minimum at x, but the heavier the rim of the flywheel, the less will the variation be to store up and give out a given quantity of energy, and it is necessary to so design it as to keep the fluctuation co-efficient within a certain percentage of the mean, this depending on the nature of the work to be done. Calling this co-efficient S, we have

$$S = \frac{Vy - Vx}{V}.$$

Where V = mean velocity = $\frac{Vx + Vy}{2}$

approximately, and the following are a few of the ratios as given by Prof. Unwin :—

Electric lighting machinery ...	... S = ·0066
Spinning machinery	... S = ·02 to ·01
Textile machinery	... S = ·025
Machine tools...	... S = ·028
Pumping engines	... S = ·05
&c. &c.	

Now the kinetic energy of a moving body

$$= \frac{W V^2}{2g},$$

where W = total weight of rim in lbs., and V = velocity in feet per second at radius of gyration (practically mean radius of rim).

If the velocity is changed from one value to another (say from x to y in Fig. 5), then energy =

$$\frac{W(Vy^2 - Vx^2)}{2g} \quad . \quad . \quad . \quad 1.$$

Now, it may be assumed that the weight of arms and boss do not affect the energy of rotation to any extent, and consequently their weight may be neglected, as the error is in favour of steady running. Now equation 1 equals the amount of energy to be absorbed by the fly-wheel, and must be equal to the excess energy area E multiplied by the area of piston, as the area E only represents foot lbs. *per sq. in.* of piston area. If P = mean pressure in lbs. per sq. in. of this energy area (measured to the same scale as the indicator diagram), and A = area of piston in square inches, we have

$$\frac{W(Vy^2 - Vx^2)}{2g} = P \times \overline{xy} \times A = E,$$

where $\overline{xy}$ is measured to the same scale as the crank pin circle, and is expressed in feet.

But if $V = \frac{1}{2}(Vx + Vy)$ then equation 1 becomes

$$E = \frac{W(Vy - Vx)V}{g},$$

and as $S = \frac{Vy - Vx}{V}$, we get

$$E = \frac{WSV^2}{g}$$

$$\therefore W = \frac{gE}{SV^2}.$$

In the foregoing, it was assumed that the resistance to be overcome was constant; if now, as is often the case, the resistance varies, it is necessary to plot the varying resistance in the form of a curve, as in Fig. 6, and it will be seen that the diagonally shaded area is the excess, and the horizontally shaded area the deficit, of energy as before, and these will be equal over any complete cycle. The resistance cycle however, may extend over a number of revolutions, but the area E for the above formula is, of course, the *maximum* excess (or deficit), energy area as before.

The Construction of Docks.

By ALEXANDER MacLACHLAN, A.M.Inst.C.E.

THE construction of modern docks, fitted as they are with all the most recent and up-to-date mechanical appliances for the manipulation of cargoes, and the discharge and shipment of goods, is a much more difficult and arduous undertaking than the building of the docks of forty or fifty years ago, devoid, as they were, of all but the most primitive and elementary arrangements for shipping or unshipping of merchandise.

From the greatly increased size of steamers, docks now-a days have to be of large area—long, wide and deep; with ample land about them, to give room for goods sheds, warehouses, storage and railway approaches.

Docks are exceedingly varied in form and size, according to the shape and extent of the available sites. Their size may vary, less or more, from 3 to 100 acres, and generally they are of an oblong shape. The typical forms of docks, other than the plain oblong or square, are shown in Figs. 1 to 5. For a 5-acre dock, a good proportion is a length of 726 ft. by 300 ft. wide. For a dock of 10 acres a length of 968 ft. and a width of 450 ft. For a dock of about 15 acres, 1,307 ft. long and 500 ft. wide. When about and above 15 acres, docks are now usually made, according as the available area is narrow or wide, with a wide swinging basin, square or nearly square, and one long, narrow basin, as in Figs. 1 and 9. With two narrow basins or branch docks of, say 1,000 ft. to 2,500 ft. long and a jetty between, as in Figs. 2, 10 and 14. With three basins and two jetties, as in Figs. 3, 14 and 16. With a number of jetties, as in Figs. 4, 18 and 19; or with two long branch docks and a swinging basin in the centre, as in Fig. 5. The long narrow basins or branch docks should, where possible, not be less than 300 ft. wide, and the large jetties shown in Figs. 2 and 3. The swinging basins of Figs. 1, 2, 4 and 5 may be about 800 ft. to 1,000 ft. square. The water spaces between the short jetties of Fig. 4 may be from 150 ft. to 400 ft. or more, according to circumstances.

These outline forms of docks shown are more or less modified to suit the varied sites and positions occupied, and the ground at disposal for such works.

Figs. 2, 3 and 4 show methods of increasing the quayage of docks by jetties, giving additional room for berths, sheds and railways where the narrowing of the waterway cannot be avoided, or is not of so much importance.

Fig. 6 is another method of increasing the berthing accommodation by overlapping of berths, allowing ships to take in a cargo—say, of coals, iron or copper ore, etc.—at extreme hatchways when the closeness of the fixed hoists, tips or cranes would prevent this being done for large-sized vessels on a straight line of quay. This system may be adopted in the jetties or in the main walls of a dock. Figs. 20 to 22.

The proportion of land area about a dock to the water area may be anything from 2 to 15 of land to 1 of water. To work a dock to the best advantage plenty of ground is required about it. Where a general traffic is carried on, the proportion of land may be at least 3 to 1, and, where possible, 5 to 1 of the water area of a dock. Where a mineral traffic is done, from 5 to 10 times the area of the water space may be required to efficiently work a dock.

Generally speaking, the width of the quays of a dock should not be less than at least half or two-thirds the width of the dock at its widest part. The average width of the main quays of a dock when the ships work on one side, should in no case be less than 300 ft. Anything less than this width is certain to hamper the traffic of any ordinary-sized dock used for

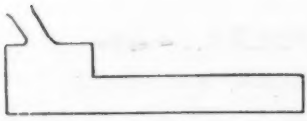


FIG. 1

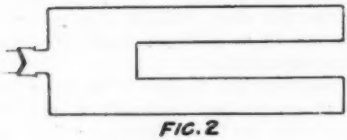


FIG. 2

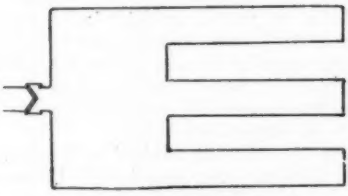


FIG. 3

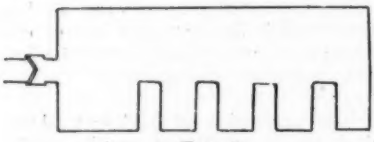


FIG. 4

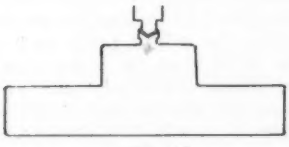


FIG. 5

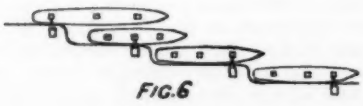


FIG. 6

general purposes and doing a brisk trade. Of course, there are many docks on banks of rivers with very narrow quays, but they would not be so constructed now; at least, if land were at all available to have wider quays.

With the shipping on both sides, such as a river on one side and a dock on the other, or a dock on each side, the main quays should be increased to 500 ft. wide. This width allows sheds or warehouses of from 60 ft. to 120 ft. wide, or more, with room for railways and roads for working the traffic, and space for storage on the ground of goods that do not spoil with the weather.

With a double line of rails between the dock and the sheds, setting the front rail 6 ft. from the quay face, and the back rail about $4\frac{1}{2}$ ft. from the sheds, a space is taken up of 27 ft. With a shed over all 103 ft. wide, a space at the back of about 37 ft. for three lines of rails and clearance—two lines for the sheds and one through line—and a roadway of 40 ft., there is left a space of only 91 ft. for storage of goods or for other railway lines, out of the 300 ft. width of quay, taking 2 ft. off for the thickness of a boundary wall.

For large docks the sheds may be required 120 ft. wide or more, in two spans of 60 ft. or three of 40 ft. With two railway lines on the dock side, space for the rails of movable cranes may be necessary, which lines will take up together at least 36 ft. With sheds 124 ft. wide over all, 48 ft. for two lines for working the sheds and two lines for through roads at the back, a width is given of 208 ft., which, doubled for both quays of river and docks as before mentioned, is 416 ft.; and, adding 40 ft. of roadway, leaves only 44 ft. for storage on the quays or railway lines; and if a roadway of 60 ft. is allowed, 24 ft. for storage or other lines out of 500 ft. width of quays.

For shipment of coal, iron, or copper ore, or other minerals, by means of staiths, hoists, or cranes, to avoid as much as possible the use of turntables—which always cause delay in shipping—the width of quays for large docks should not be less than 500 ft. This width is

required so that curves of sufficiently large radii may be used for the railway approaches, to bring the wagons fair on or end on to the quays.

In addition, space is needed for standage or storage room for the wagons containing the minerals for shipment, for shunting purposes, or for through traffic. As many as 20 or 30 lines of single railway may be necessary for storage or marshalling purposes, taking up — allowing a 6-ft. way between each single line — about 211 ft. and 322 ft. extra width to that allowed for railway approaches to the coal-shipping machinery. That is to say, that a width of quay may be needed of at least 700 ft. to 800 ft. for coal and other mineral traffic.

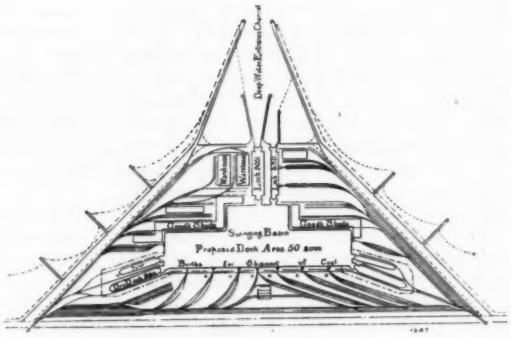


FIG. 7.—DOCK PROPOSED BY AUTHOR.

Besides room for shipment of minerals, care must be taken to provide ample space for the timber trade, even in a dock for general purposes. Timber is taken from the ships and often stored for a time on the quays. The different sizes of wood are laid down on timber ground in assorted lengths, qualities, and lots belonging to each merchant. Besides this temporary storage of timber, ground should be available for more permanent lots; access roads about 18 ft. wide being provided between the different piles of timber.

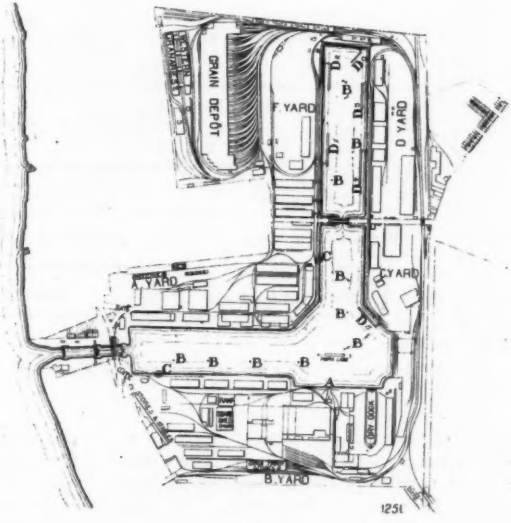


FIG. 8.—MILLWALL DOCKS (MILLWALL DOCKS COMPANY).

For a dock devoted to general traffic, an average allowance of land for storing timber is about one-third of an acre per acre of dock area.

The shed accommodation for storage of general goods may be made equal to one-third the dock area.

From 1 to 5 acres of ground for standage of wagons may be required for each coal hoist, tip, or crane.

Unless a deep-water dock is intended

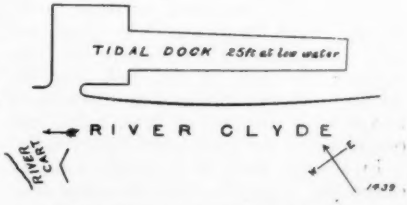


FIG. 9.—CLYDEBANK DOCK (CLYDE TRUST).

directly opening into a river or harbour, there may be wanted a lock with two or three pairs of gates, having the extreme pairs of gates far enough apart to take in the largest vessels likely to come into the port. Taking into account the greatly increased length of steamers made of late, the lock gates may be from 450 ft. to 750 ft. apart, or even 800 ft., allowing for possible future increase.

The width of the entrance to a dock may be for a length of 450 ft., at least 65 ft. to 75 ft.—80 ft. would be better, to allow plenty of clearance. For a 750-ft. length of entrance between gates, a width of not less than 80 ft. to 90 ft., or 100 ft., may be advisable. Battleships require a

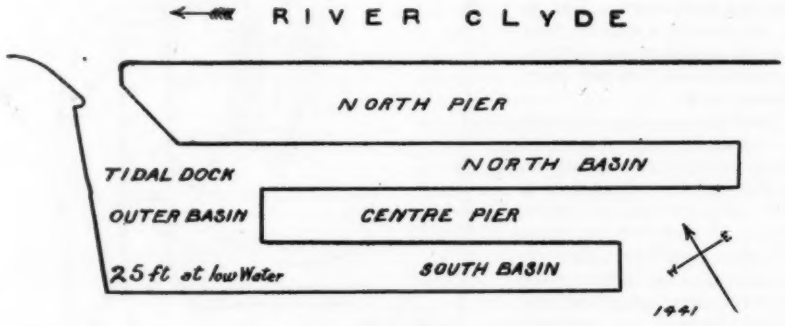


FIG. 10.—SHIELDHALL DOCK (CLYDE TRUST).

width of entrance of about one-fifth of their length to pass into dock, traders one-seventh to one eighth, and large liners from about one-ninth to one-tenth. To this must be added plenty of clearance.

In order to utilise to the utmost the quayage of locks, they may be so increased in width as to give room for ships to lie alongside and discharge, while others are passing to and from the docks. For this purpose the body of the lock may be made 100 ft. wide recessed on one side, or 200 ft. wide recessed on both sides, and contracted at the gates. See Figs. 5 and 7.

In a large dock, or a group of docks connected together and communicating with the sea through one entrance, it has been thought a risk to have only one means of communication, in case of damage or breakdown of the gates, etc. Therefore, two entrances are considered desirable, through either of which traffic may pass uninterrupted, should any repairs be required, or mishaps occur to the entrance gates or machinery.

Some docks have half-tide basins. These are sometimes made one-third to one-tenth of the dock area, and are usually square or nearly square in shape. One-third area will commonly be found a good proportion. But two or three docks may enter from this basin of a large united area, and the same may be said of tidal basins.

Should an outer tidal basin be needed this may be made, if room is restricted, from one-fourth to one-eighth of the dock area, and bell-mouthed at the entrance.

In providing wet-dock accommodation provision should be made for dry or graving docks for repairing vessels, inside as well as outside the gates of the wet docks, at places not likely to interfere with the general traffic.

The dry docks must not awkwardly cut up the line of quays, cross the lines of communication, monopolise valuable berths or ground, or contract unduly access to other parts of the dock and harbour.

Besides room for engine and boiler-houses, proper width should be given for working the graving docks, ground for

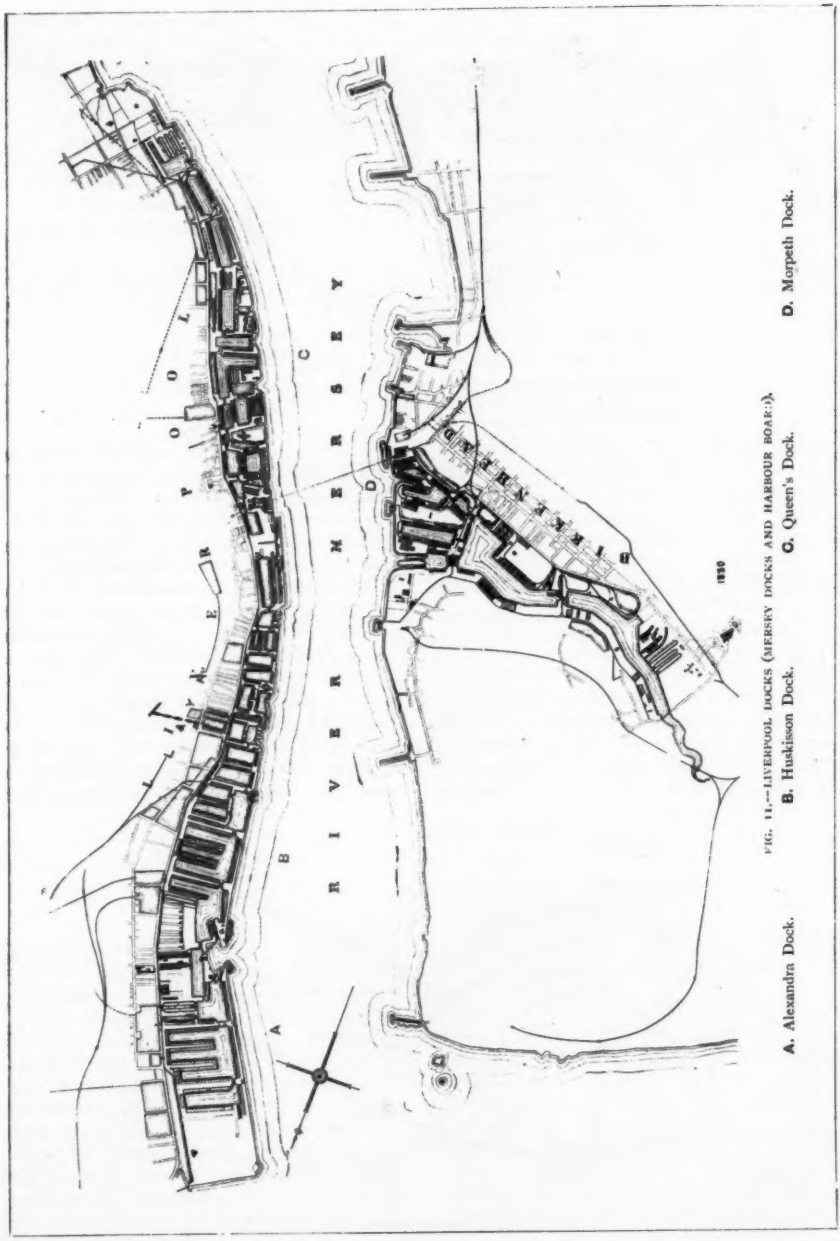


FIG. 11.—LIVERPOOL DOCKS (MERSEY DOCKS AND HARBOUR BOARD).

A. Alexandra Dock. B. Huskisson Dock. C. Queen's Dock. D. Morpeth Dock.

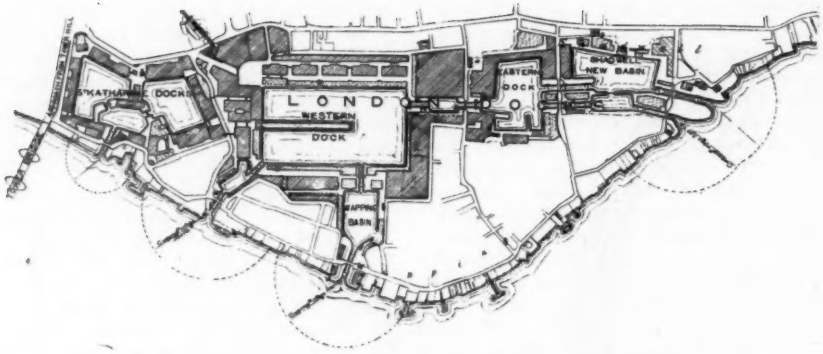


FIG. 12.—LONDON DOCKS: WESTERN DOCK (LONDON AND INDIA DOCKS JOINT COMMITTEE).

shores, trestles, etc., and also room for possible extension—often a very necessary precaution.

For modern requirements, dry-dock accommodation should be provided of 50 ft. to 70 ft. lineal per acre of dock area. Small docks may need 75 lineal feet per acre of wet-dock area.

If at all possible, when settling the area of ground to be reclaimed, acquired, or taken in for dock works, land should either be reclaimed or included in the scheme for future extension (Fig. 17). This, if done at first, may prove a great saving, as, almost invariably, docks are sooner or later needed to be extended; or additional ground is wanted for separate docks or timber ponds, or storage space or more land for buildings. When this land question is sufficiently attended to, vast sums may be saved in additional expenditure for new reclamation embankments.

When deciding on the size of a dock, by all means let it be large enough for all possible increase for at least ten years after the dock shall be finished. For, when a dock is completed, the sheds and warehouses and other buildings built, the machinery erected, the railways and roads and other works constructed, and all in working order, the trade has invariably so greatly increased that the cry is for another

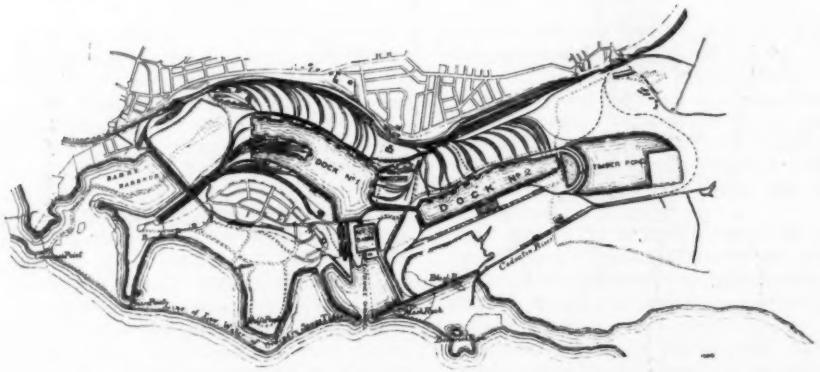


FIG. 13.—BARRY DOCKS (BARRY RAILWAY COMPANY).

dock, or a big extension, more graving docks, land, etc.

The multiplicity of small docks—each with its own reclamation embankment, entrance basin, entrance or entrance lock and gates, and opening and closing machinery, entrance bridge, etc., with dock-gatemen and others necessary to attend the dockhead, etc.—is a very expensive way of increasing the dock area of a port.

When reclamation embankments are constructed on a long stretch of flat beach parallel to the line of the shore, and returned into the land enclosing the reclaimed area for docks or quay space, a short extension of the sea-wall at the returned ends may enclose a very much larger extent of additional area, by carrying the parallel part of the embankment farther out into the water, which may but vary, if at all, in depth but a few feet. Also, advantage should be taken of any sandbanks, rocks, or shallows, upon which to found the reclaiming wall, even though the area thereby enclosed may be more than that required for present purposes. The extra area taken in, if not for dry docks or wet docks, may be used for timber ponds, or levelled up as required for additional buildings, quays, or ground for letting purposes.

In settling on sites for harbours and dockworks, railway facilities must be taken carefully into account. In works carried out by public trusts, a healthy rivalry between railway companies, two or more, is desirable; rather than the dock to be at the mercy of one railway company, which, it not allowed full control, sooner or later, may cripple or altogether bankrupt the undertaking.

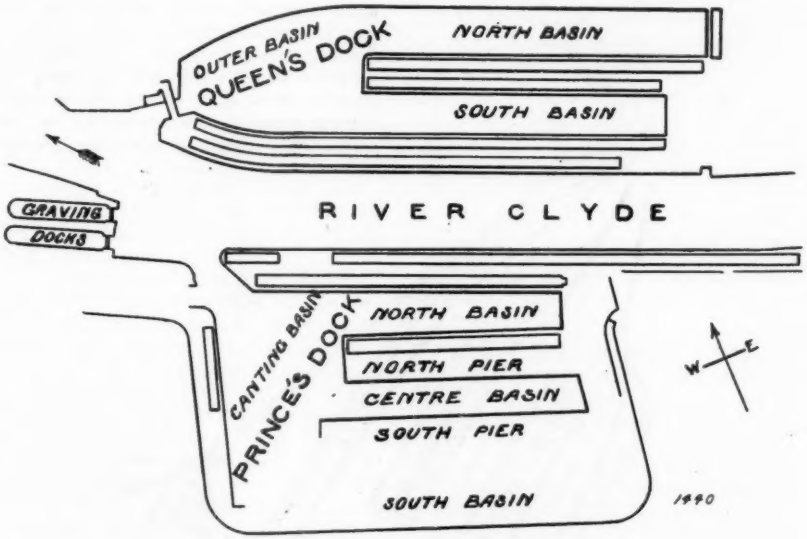


FIG. 14.—QUEEN'S AND PRINCE'S DOCKS (CLYDE TRUST).

Many a good scheme has been financially wrecked for want of proper and adequate railway access to the site of the works, and for lack of room on the ground for standage and storage of coal and other minerals.

Of late the tendency has been to do away with dock gates and all their expensive accessories; such as opening and closing machinery, sluices, inverts, sills, etc., and

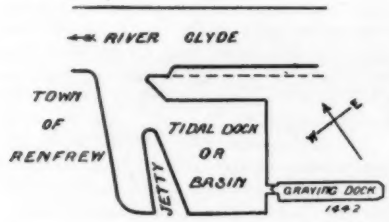


FIG. 15.—RENFREW PROPOSED DOCK.

have deep-water open docks accessible at all times of the tide, with a depth at low-water spring tides of, say, 25 ft. to 30 ft., increasing at high water to 35 ft. to 40 ft., depending on the rise of tides. The deep-water open dock entrance can then be made wider throughout, and may range from 150 ft. to 350 ft. See Figs. 1, 9, 10, 14, 15 and 17.

These deep-water open docks are the docks of the future, and are only possible nowadays because of the great perfection to which dredging plant and machinery have been brought in maintaining deep-water channels to the sea.

Against the great expense of deep-water docks, deeper walls, increased excavations and maintenance by dredging of deep-water channels, are placed the large first cost of entrance locks, gates, machinery, and cost of maintenance. The very great boon of ships being able to enter and leave a dock at all times of the tide—a most desirable consideration, and one which will soon become an absolute

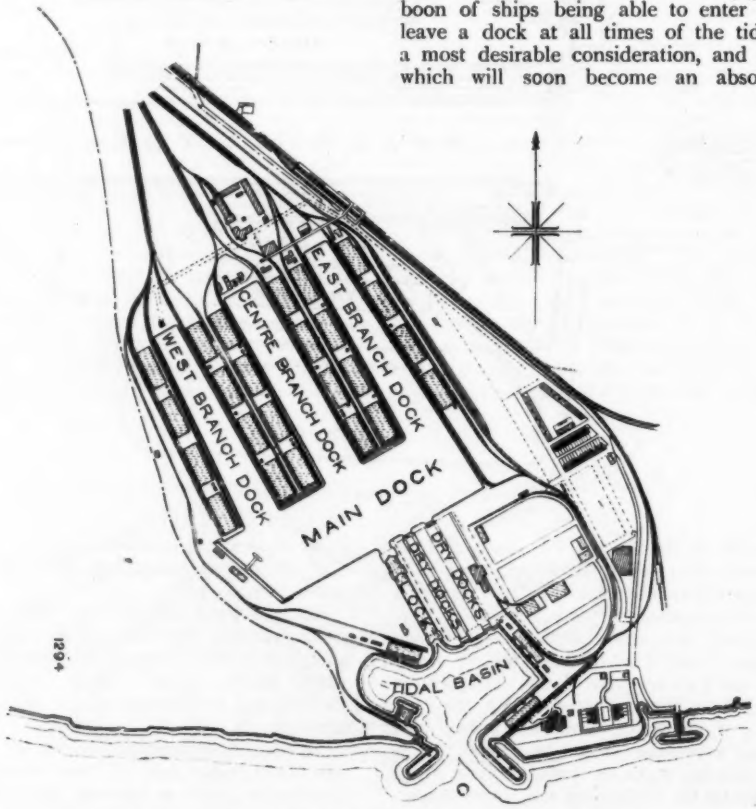


FIG. 16.—TILBURY DOCKS (LONDON AND INDIA DOCKS JOINT COMMITTEE).

necessity in these days of keen competition and quick shipments—will bring deep-water open docks into universal use, even though their initial cost may be in excess of the older method, with all its aggravating delays and inconveniences.

The cost of docks varies considerably compared to the water area enclosed, depending, as it does, on the style the dock works are got up, the depth of water, nature of walls, reclamation embankment, proportion of included reclaimed land, dredging of channels, etc. A dock of average size may cost, without equipment, from about £15,000 to £25,000 an acre of water area enclosed, and with equipment from £20,000 to £35,000 an acre.

Fig. 7 is a plan of a scheme by the author for a dock of about 50½ acres, modelled after the form of dock in Fig. 5, showing access at the ends for rival railway companies.

The main entrance to the dock is shown widened out to 200 ft., so that it can be used for shipping or discharging cargoes while vessels are entering or leaving the dock. A second entrance, but narrower, recessed on one side only, is also shown. The distance between the gates of each entrance is 850 ft., and at the gates the main entrance is contracted to 100 ft., and the other to 90 ft.

Jetties, 800 ft. long by 25 ft. wide, run out on each side of the principal dock-

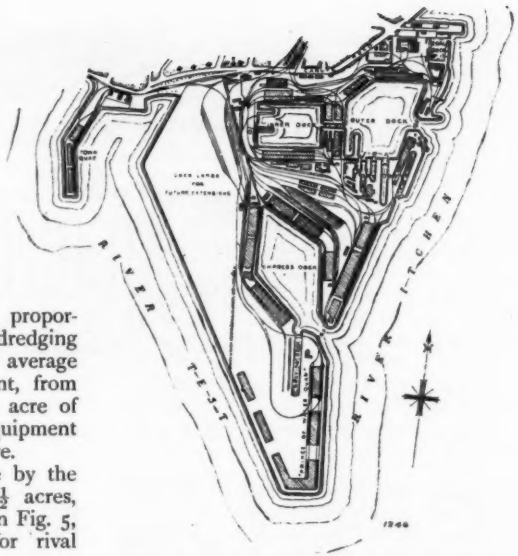


FIG. 17.—SOUTHAMPTON DOCKS (LONDON AND SOUTH-WESTERN RAILWAY COMPANY).

head into the harbour, which is 52½ acres in area, and provided with beaching grounds for ships, or for slipways, floating pontoon dry docks, gridirons, etc.

The harbour is formed by two breakwater piers, converging seaward, with an opening at the outer ends, forming the entrance to the harbour, of 400 ft.

A deep-water channel is maintained by

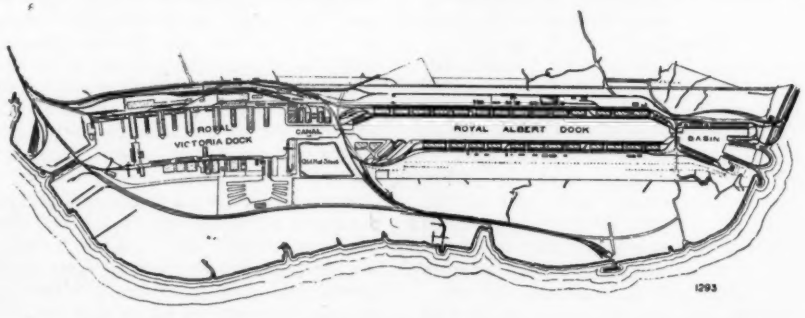


FIG. 18.—ROYAL VICTORIA AND ALBERT DOCKS, LONDON (LONDON AND INDIA DOCKS JOINT COMMITTEE).

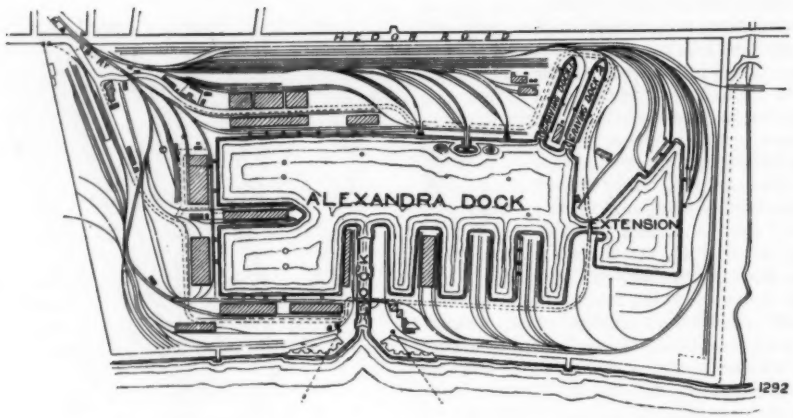


FIG. 19.—ALEXANDRA DOCK, HULL (HULL, BARNSLEY RAILWAY AND DOCK COMPANY).

dredging from the dockhead to the outer piers, and beyond into the sea.

There are four graving docks provided, two 900 ft. long, and two 700 ft., a total of 3,200 ft., or about 63⅓ ft. per acre of wet dock. These dry docks may be made with inner gates, so that they may be shortened or lengthened as required, to accommodate two or more ships at a time.

Along the shore, outside the sea-barriers, groynes are thrown out to break the force of the waves on the reclamation embankments and to gather beach.

The proportion of enclosed land to the water area is five times, and ample railway approach lines to the berths and standage for minerals are given.

The quays are not less than 800 ft. wide. Shed and warehouse accommodation is attended to, and ground for timber, deal yards, etc., is allowed.

The dock is 3,000 ft. long, and not less than 600 ft. wide, with a swinging basin in the centre of 1,000 ft. square, into which the entrance locks open.

This dock is proposed principally for the export of coal, and the import of timber, grain and general merchandise.

(To be concluded.)

Some Remarks on the Compound Explosion Engine.

By E. BUTLER, M.I.Mech.E.

THE compounding of an explosion or internal combustion engine appears to be an attractive and peculiarly difficult problem, judging by the number of attempts at its solution covering the period over the last twenty years or so.

In an explosion engine the temperature of the gases, after combustion ceases, rapidly falls, owing to their comparative low latent heat value; and it may be instanced here that for a given initial pressure of, say, 15 atmospheres in a cylinder developing a mean pressure of 75 lbs. per square inch on the piston, the weight of the gases in an explosion cylinder is only one-fifth of the steam or compressed air that would be required to expand to a corresponding degree, with the result that for any slight defect in the cylinders, piston, or valves, a corresponding increase of leakage will occur.

Then, again, the hot rarefied gases in the explosion engine cylinder are unavoidably surrounded on all sides by water-cooled walls, which absorb more than two-fifths of the total heat available.

A reference to the diagrammatic section on page 393 of a 100-i.h.p. compound engine designed by the writer will considerably assist in demonstrating the behaviour of the explosive gases in a four-cycle compression engine with two explosion cylinders, each alternately exhausting into a third expansion cylinder, the relative areas of the pistons being as 2·2 to 1.

In this engine the cranks of the two explosion cylinders are set at even angles, and 165 degs. in advance of the expansion cylinder crank. This disposition of the crank angles results in a more rapid expansion of the gases in their transference from the high to the low-pressure cylinder, and adds to the power obtained, as compared with expansion in one cylinder, or in two cylinders with their pistons connected to cranks at opposite angles.

The exact advantage gained is seen in the difference of the cross-hatched areas in the superposed diagrams, also by reference to the pressure line *X* on the explosion cylinder crank circle and the line *N* on the expansion cylinder crank circle. The hatched diagram indicates an actual working expansion in the explosion cylinder.

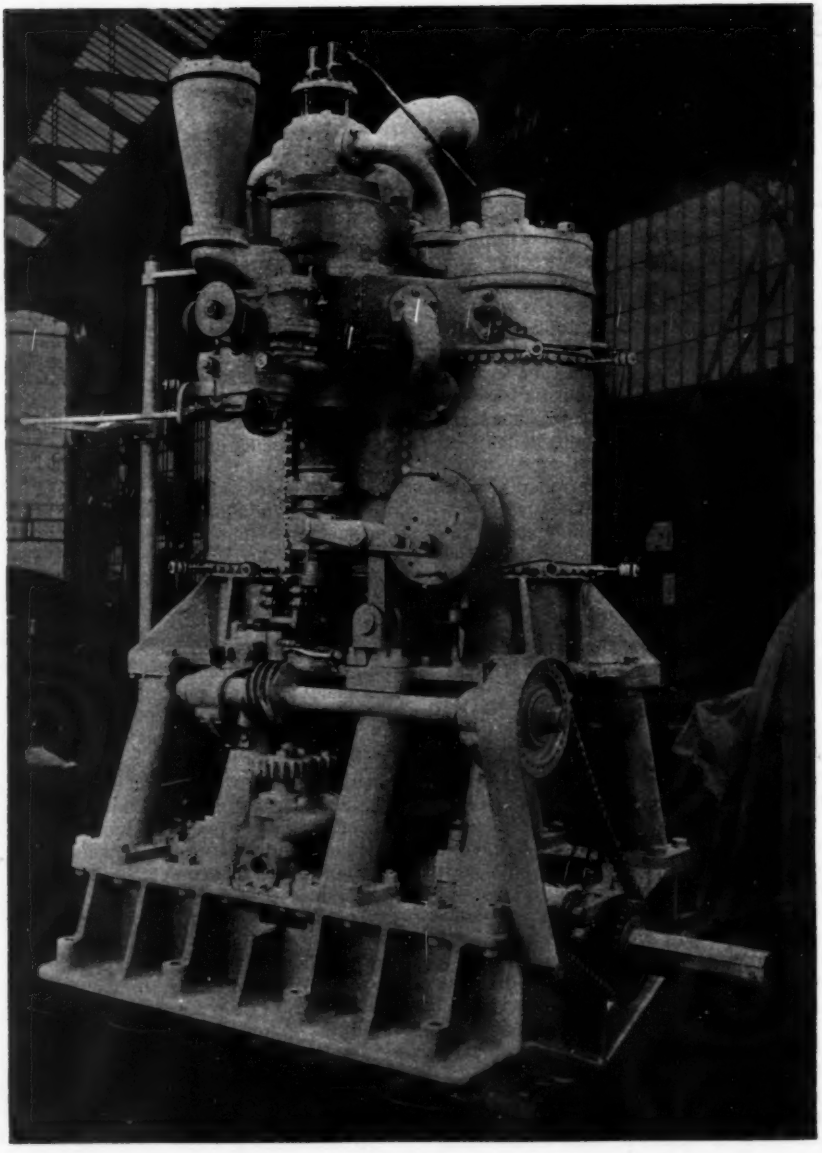
The resultant pressures transmitted to the cranks are illustrated graphically by the suction, compression, explosion, and exhaust lines *S C P X*, for a cycle of two revolutions, and shows very clearly the *modus operandi* of an explosion engine of four cycles. The pressure line *N* and exhaust line *O* are repeated on the expansion cylinder crank at each revolution this cylinder being put into communication with one of the two explosion cylinders alternately.

The curve *A* represents an adiabatic expansion from a maximum temperature of 4,800 degs. Fahr., and indicates the theoretical fall of pressure due to change of volume and temperature. This is the curve of the perfect engine.

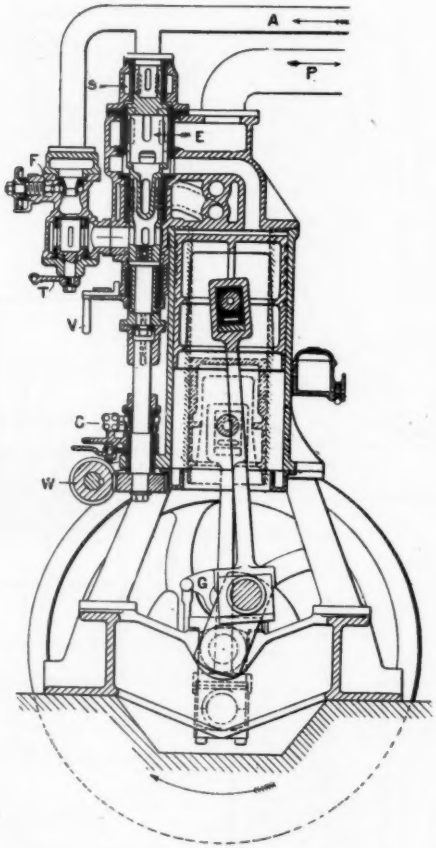
The line *B* is an isothermal curve at the reduced temperature of 2,400 degs. Fahr.

The adiabatic curve *C* indicates the fall of pressure due to change of volume and of temperature from 2,400 degs. and illustrates the extreme possibilities of expansion of the gases, assuming combustion to be complete at the moment of ignition at highest compression, with a loss allowance for radiation of 50 per cent.

In determining these pressures a mixture of town gas of 1 to 10, and of a value of 640 B.T.U. per cubic foot at a



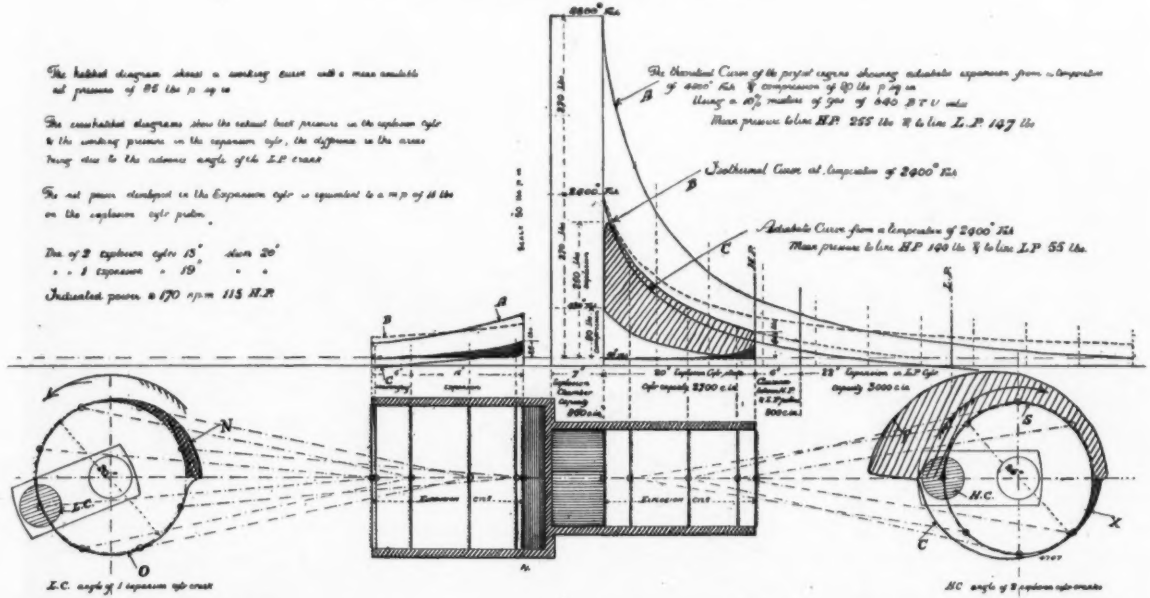
EXTERNAL VIEW OF 100-H.P. THREE-CYLINDER COMPOUND EXPLOSION ENGINE.



CROSS SECTION THROUGH EXPANSION CYLINDER OF 100 H.P. COMPOUND EXPLOSION ENGINE.
(BUTLER'S SYSTEM.)

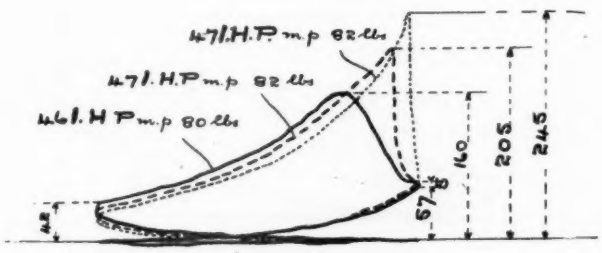
A, air pipe; *C*, commutator; *E*, exhaust control; *F*, gas feed adjustment; *G*, shaft governor; *P*, exhaust pipe; *S*, scavenging air distribution; *T*, throttle valve lever; *V*, valve expansion adjustment; *W*, gear wheels, ratio 4 to 1.

DIAGRAMMATIC ARRANGEMENT SHOWING THE PROPORTIONS OF THE CYLINDERS, CLEARANCES, CRANK ANGLES, AND THE THEORETICAL AND MARKING DIAGRAMS OF BUTLER'S THREE-CYLINDER COMPOUND EXPLOSION ENGINE.

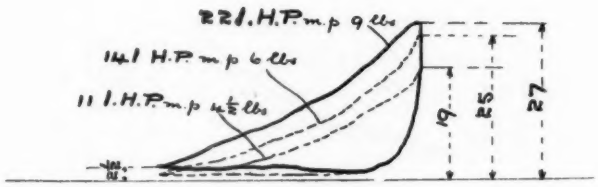

The hatched diagram shows a working curve with a mean available pressure of 95 lbs p. sq. in
The cross hatched diagrams show the exhaust back pressure in the explosion cylr & the working pressure in the expansion cylr, the difference in the areas being due to the advance angle of the LP crank
The net power developed in the Expansion cylr is equivalent to a m.p. of 18 lbs on the explosion cylr piston.
Dia of 2 explosion cylrs 15" diam 20"
" " 1 expansion " 19" " "
Indicated power @ 170 r.p.m 115 H.P.
The theoretical Curve of the perfect engine showing adiabatic expansion from a temperature of 4000° Fah & compression of 80 lbs p. sq. in
Using a 40% mixture of gas of 640 B.T.U. value
Mean pressure below H.P. 255 lbs & below L.P. 147 lbs
Isothermal Curve at temperature of 2400° Fah
Adiabatic Curve from a temperature of 2400° Fah
Mean pressure below H.P. 140 lbs & below L.P. 55 lbs
4000° Fah
2400° Fah
270 lbs
200 lbs
80 lbs
H.P.
L.P.
B
C
7" Explosion Clearance Capacity 2000 c.in.
20" Explosion Cylr. stroke Cylr capacity 2200 c.in.
6" Clearance between H.P. & L.P. Pistons 800 c.in.
22" Expansion in L.P. Cylr Capacity 3000 c.in.
Expansion Cylr.
Explosion Cylr.
L.C.
H.C.
N
O
S
X
L.C. angle of 1 explosion cylr crank
H.C. angle of 2 explosion cylrs cranks

LC Angle of one expansion of cylinder crank.
N Diagram of pressure on crank on expansion stroke. Mean forward thrust, 8 lbs. p. sq. in.
O " " exhaust " " backward " 1½ " " "
Net power thrust on expansion cylinder piston, 6½ lbs.
" " developed, 15 I.H.P.

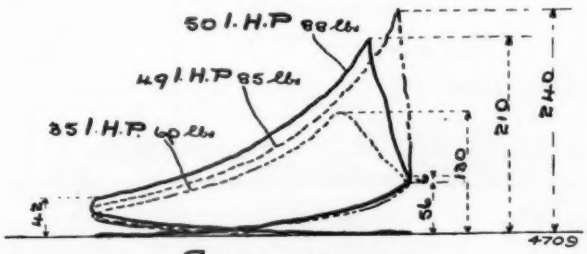
Mean forward thrust, 117 lbs. p. sq. in. *P* Diagram of pressure on crank on explosion stroke.
" backward " 6 " " " *X* " " " exhaust "
" " " 2 " " " *S* " " " admission "
" " " 24 " " " *C* " " " compression "
Net power thrust on explosion cylinder piston, 85 lbs. p. sq. in.
" " developed, 99 I.H.P.



SCALE 100 LBS



SCALE 16 LBS



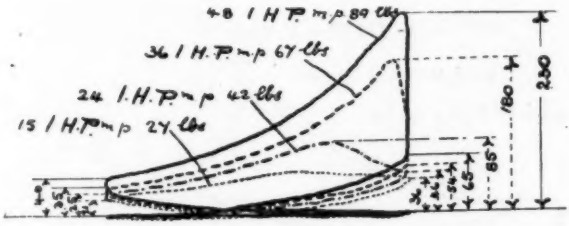
SCALE 100 LBS

Revolutions, 175 per minute.
Mean total I.H.P., 105.
Brake H.P., 75 to 78.

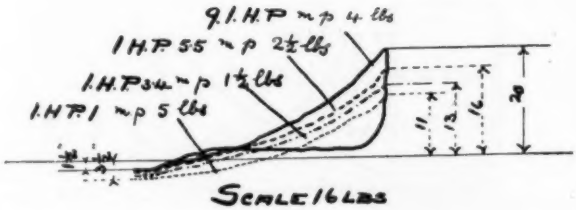
Diameter of two explosion cylinders, 13 ins.
" one " " 18½ "
Stroke, 20 in.

DIAGRAMS TAKEN FROM BUTLER'S COMPOUND EXPLOSION ENGINE, WITHOUT SCAVENGING ACTION, USING BENZOLINE SPIRIT, AT VICTORIA WORKS, GATESHEAD-ON-TYNE.

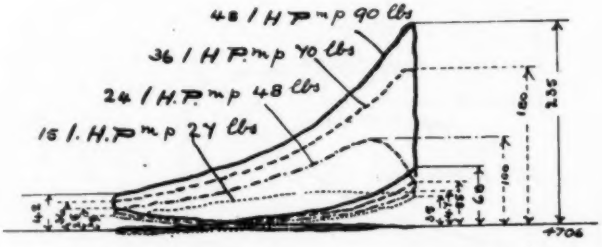
Prony brake on wheel running in water and covered in and used with two Salter balances and tachometer.



SCALE 100 LBS.



SCALE 16 LBS



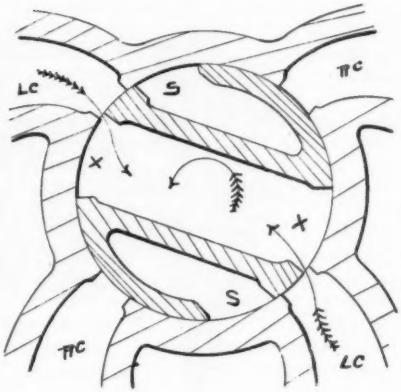
SCALE 100 LBS.

Revolutions 158 on full load of 75 to 77 B.H.P., 105 I.H.P.
" 160 " ¾ " " 50 " 52 " 77 "
" 163 " ½ " " 30 " " 51 "
" 165 " ¼ " " 10 " " 31 "

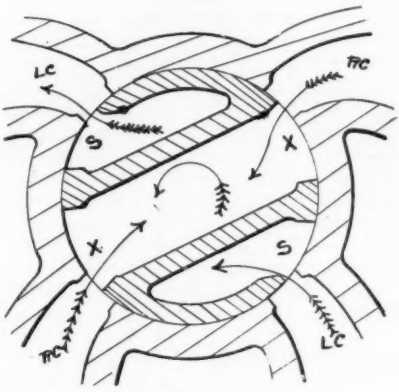
DIAGRAMS TAKEN FROM BUTLER'S COMPOUND EXPLOSION ENGINE, USING TOWN GAS, WITH SCAVENGING ACTION, AT VICTORIA WORKS, GATESHEAD-ON-TYNE.

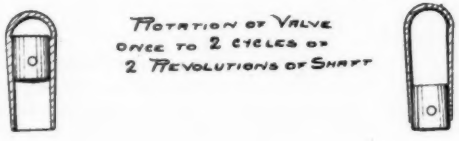
Prony brake on wheel running in water and covered in, used with two Salter 400 balances, and variation of speed shown by tachometer.

Position of valve with cranks of explosion cylinders on top centre.



Position of valve with cranks of explosion cylinders on bottom centre.

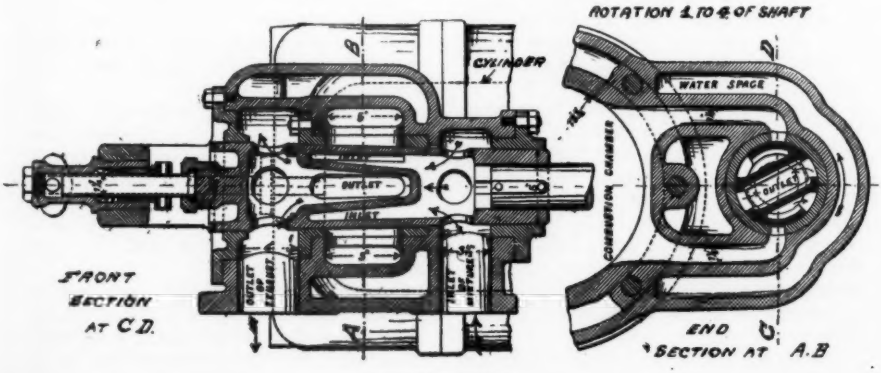




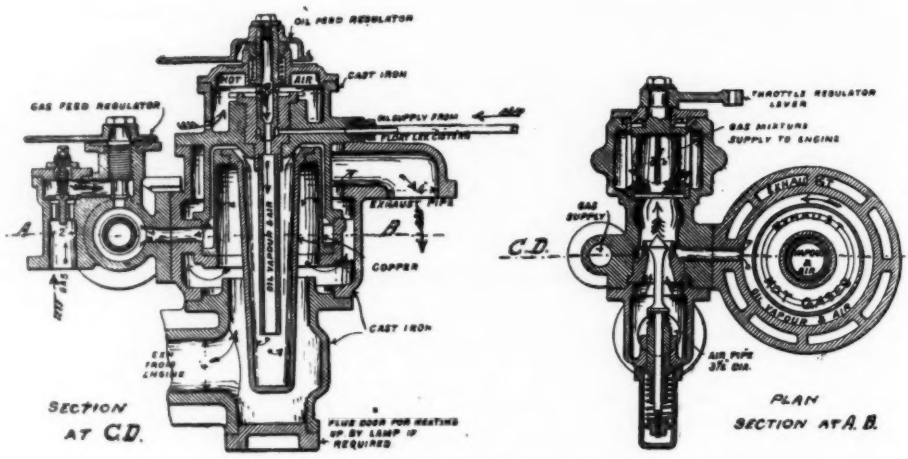
LC Portways leading to left-hand cylinder.
RC Portways leading to right-hand cylinder.

S Admission ports in valve.
X Exhaust ports in valve.

VALVE OF BUTLER'S THREE-CYLINDER 100 I.H.P. EXPLOSION ENGINE.



DETAILS OF VALVE.



VOLATILIZER, MIXER, AND THROTTLE REGULATOR FOR BUTLER'S COMBINED GAS AND OIL ENGINE.

compression of 80 lbs. per square inch is assumed. With gas of this quality 4 cubic feet would develop 1 i.h.p. for one hour in a theoretically perfect engine.

The two drawbacks attached to the explosion engine, due to the rapidly-falling pressure of the gases arising from expansion and by absorption to the cooled cylinder walls, are to a considerable extent counterbalanced by the "delayed combustion" which obtains in actual practice. From this cause the pressure of the gases is maintained considerably above that resulting from adiabatic expansion, and more nearly approaches the line of constant temperature. The expansion curve of combustion is seen to fall between the two curves *B* and *C*.

There is thus a considerable pressure of the gases seen to be available at the end of the explosion stroke, which, after filling unavoidable clearance space between the two pistons, is shown to give a useful net power in the low-pressure cylinder equivalent to an additional 10 lbs. to 12 lbs. mean pressure in the high-pressure cylinder, resulting in an increase of the total mean pressure from 85 lbs. to 96 lbs. per square inch.

The capacity of the low-pressure cylinder is sufficient to expand the gases down to the atmospheric line at about $\frac{5}{8}$ to $\frac{3}{4}$ stroke. The piston thence serves as a pump for clearing out the burnt inert gases from the explosion chambers, and by this means considerably increases the working capacity of the engine when using town or producer gas.

The two series of diagrams on pages 395, 396 are copies from actual cards taken from one of four 100-h.p. vertical engines at the Victoria Works, Gateshead, illustrated on page 392. One series on town gas and one on benzoline, the test was made with a prony-brake, provided with a dash-pot and balanced on a water-cooled fly-wheel 5 ft. 7 ins. diameter by 12 ins. width, the mean speed of the engine being 170 revolutions per minute.

Each load line on the cards is the mean of some 40 explosions and shows the extreme regularity of the running of one of these engines governed on the *change of volume* principle as now very generally being adopted by all makers of explosion engines for large powers and for light motor work.

The mixture of air and town gas or producer gas, oil or spirit is formed in an inspirator and is thence fed to a specially constructed throttle-valve controlled by a large shaft-governor, the method used by

the writer in all engines of his design for 15 years.

In working on town gas this engine, as would be expected, is found to be more efficient when arranged to draw a clearing charge of air through the explosion chambers, but in working on benzoline the scavenging showed less advantage, and the engine ran smoother with the exhaust products retained than when cleared; the same compression of 75 lbs. was however used in each case.

On town gas an economy of 13 cub. ft. was obtained per i.h.p., which for an engine with cylinders of this small size is good. On benzoline six gallons per hour developed 80 b.h.p., which shows a b.h.p. for ·51 pint and an i.h.p. for ·408 pint. From 18 to 20 i.h.p. was obtained from the expansion cylinder when running on benzoline, which accounts to a great extent for this very economical result.

It is interesting to note that in this particular engine the distribution of explosive to the h.p. cylinders, the communication from high to low and exhaust from l.p. cylinder to the atmosphere are all functioned by one rotative balanced valve for all three cylinders. The action of this valve is shown by reference to page 397. It revolves once to two cycles of two revolutions in a seat having two pairs of portways communicating with the two explosion chambers.

The pressure is communicated to opposite sides of the valve from one cylinder, while the other is open for the admission of explosive mixture, and so on. The form of this valve is clearly shown by reference to the lower figure, which shows sections of a valve for a single-cylinder engine; arrows indicate the course of the gases. The valve is held up to its seat by a plunger at the end open to the pressure in the cylinder, and is thus permitted free-end play for expansion, and is self-adjusting for wear.

No lift-valves are used at all; five cam-controlled poppets are thus replaced with a corresponding simplicity and smoothness of action.

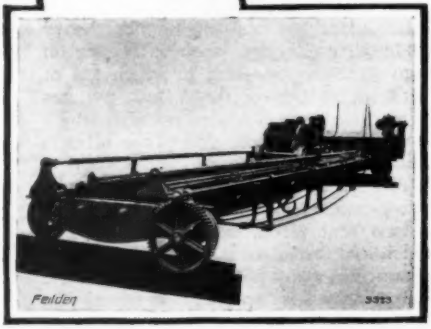
In adapting this engine for heavy crude oil a volatiliser, such as shown on page 398, can be used, in which gas or spirit is employed for a few minutes in starting to get it heated up, after which the change over from one to the other is quite easy.

The writer has designs for a double-acting compound engine, with water-cooled pistons and valves on this principle, in which four impulses at equal periods are obtained at every turn of the crank-shaft. This engine is specially designed for direct coupling to electric generators of very large capacity, and for which there is reason to expect an extreme economy.

Modern Crane Construction.

By GEO. WM. RUSHWORTH, A.M.I.Mech.E.

A CRANE is a machine used for the purpose of moving weights, and is a structure that will admit of the elevation of the load to the necessary height, and its suspension at that point, until the structure can be moved into the desired position for lowering the load.



There are several methods of affording the required overhead support, the most familiar means being—(1) a jib, projecting from the base of the crane, as in the ordinary hand derrick crane; and (2) a gantry, fixed overhead horizontally, on which the lifting portion of the crane is mounted.

A form of crane largely used by builders, contractors, and quarry owners, is the

Hand Derrick Crane.

The term derrick is now generally applied to cranes having a jib pivoted at the base, and so fitted that in addition to having a rotary motion about the axis of the post, the jib may be raised or lowered to any angle.

Derrick cranes have two winding barrels, one for raising and lowering the load, and the other for adjusting the angle of the jib.

These two winding barrels are suitably geared to the handle-shaft, from which all motions are taken. The lifting motion has two gears, single and double purchase, and in the larger sizes a snatch block is used to give treble purchase.

The jib is made from pitch pine, from 30 to 55 ft. long, in one piece, square at both ends, but thickened on the top side in the centre, so as to compensate for the sag when the weight is hoisted. The jib of a crane to lift 4 tons would be 45 ft. long, 12 ins. square in the centre, and 9 ins. square at the ends.

The greatest angle at which the jib should lift to its full capacity is 45 degs. from the upright. To find this angle, an easy method is to multiply the length of the jib in feet by 0·7, which gives the distance or radius from the centre of the crane to the fall rope, equal to 45 degs. For instance, with a jib 40 ft. long, it would be $40 \times 0{\cdot}7 = 28$ ft. The winding barrel in front of the crane body projects sufficiently to prevent the jib from being placed in an absolutely vertical position, as it would then be difficult to lower it steadily.

The top guys are secured at one end to the crane top, and at the other end to the sleeper guys. The top guys receive the pull of the crane top and jib, while the bottom guys take the thrust caused by the foot of the jib, which acts as a lever.

These forces must be counterbalanced in some suitable manner. This end may be attained by piling stone or other convenient material on to the ends of the two guys where they are bolted together, or by anchoring them into the ground. The latter is the better way if the crane is to be permanent, as it causes no obstruction round the crane.

The usual hand derrick crane, when

erected, will work three-quarters the way round before impeded by the guys, and as one guy will have to bear the whole strain when the jib is against it, the counterbalance weights should be equal to twice the weight of the load to be lifted.

In the erection of large buildings it is necessary to raise the crane as the work gets higher. Latticed wood stagings are used for this purpose, the guys being secured to the foundations by means of chains and tension screws.

Fig. 1 is an illustration of a 20-cwt. hand derrick crane, with 30-ft. jib, with the weight on the guys above the ground.

These cranes can be provided with small rollers underneath, so as to run in steel channels on buildings in course of erection, thus forming a fairly portable crane, which costs but a trifle more than the ordinary pattern.

The derrick crane can also be arranged so that the winding rope may be worked either from a friction hoist or a steam winch. The footstep is then provided with a pulley on the under side, through which the rope passes instead of being wound on the barrel, while the jib head and body top castings each have an extra sheave for the rope. The crane can then be used either by hand or power as desired.

By adding an engine or engines, and the necessary gearing, we get

The Steam Derrick Crane.

The timbers are slightly strengthened to receive the heavier gearing, and a platform is provided upon which the driver stands and controls all motions. Where two engines are employed they are suitably coupled up to the double sweep crank-shaft, which is fitted with a sliding pinion wheel, for single or double purchase, hoisting or lowering. The derricking motion of the jib is worked from the crank-shaft, either by a worm and worm-wheel, or by a catch and catch-wheel. In the former case, power is transmitted to the worm, by means of double male and female frictions, fitted with bevel gearing. The frictions are operated by means of a hand wheel, and serve to revolve the worm in either direction. The worm-wheel is keyed to the taper barrel.

In the latter case, the catch-wheel is cast upon the barrel, and the teeth are turned over in claw form, so that when the jib is being hoisted the catch slips, tooth by tooth, and takes the weight at any point. The catch is suspended above the wheel on a cross shaft secured at both ends to the upright.

The winding wheel is made of large diameter in order to get purchase, and is keyed to the winding barrel shaft and in gear with the second-motion pinion wheel. The winding barrel is of cast iron, with solid steel shaft cast in, the barrel surface being grooved where wire ropes are used. To the foundation casting is bolted an external spur wheel, into which is geared a small pinion wheel keyed on to a vertical shaft, this arrangement providing for the swivelling motion. This motion is worked by means of a worm-wheel actuated by a worm on the crank-shaft.

Reversing motion is attained by double male and female frictions on the vertical shaft, and operated by means of a hand wheel.

A flat cast-iron water tank bolted to the platform forms a base-plate for the boiler and fuel bunk.

Where an independent supply of steam is available, a swivel valve can be fixed to the centre of the crane footstep, and from this steam may be taken when the crane is turned in any direction.

Jibs from 50 to 65 ft. long are often used with these cranes, and they are preferably made of steel in **H** form, strongly stayed crosswise and diagonally. When built of timber they should be trussed on the underside with strong iron rods. For some purposes, and for very long lengths, the jib is sometimes constructed from steel channels and latticed in box form with steel strips. Cranes to lift 15 or 20 tons generally have uprights constructed of steel girders. Generally speaking, all gearing is fixed behind the uprights, so that the jib may be allowed the greatest possible variation in its radius, a point of the utmost importance, as the utility of the crane greatly depends on the area over which the jib can work.

Fig. 2 is the illustration of a 10-ton

17

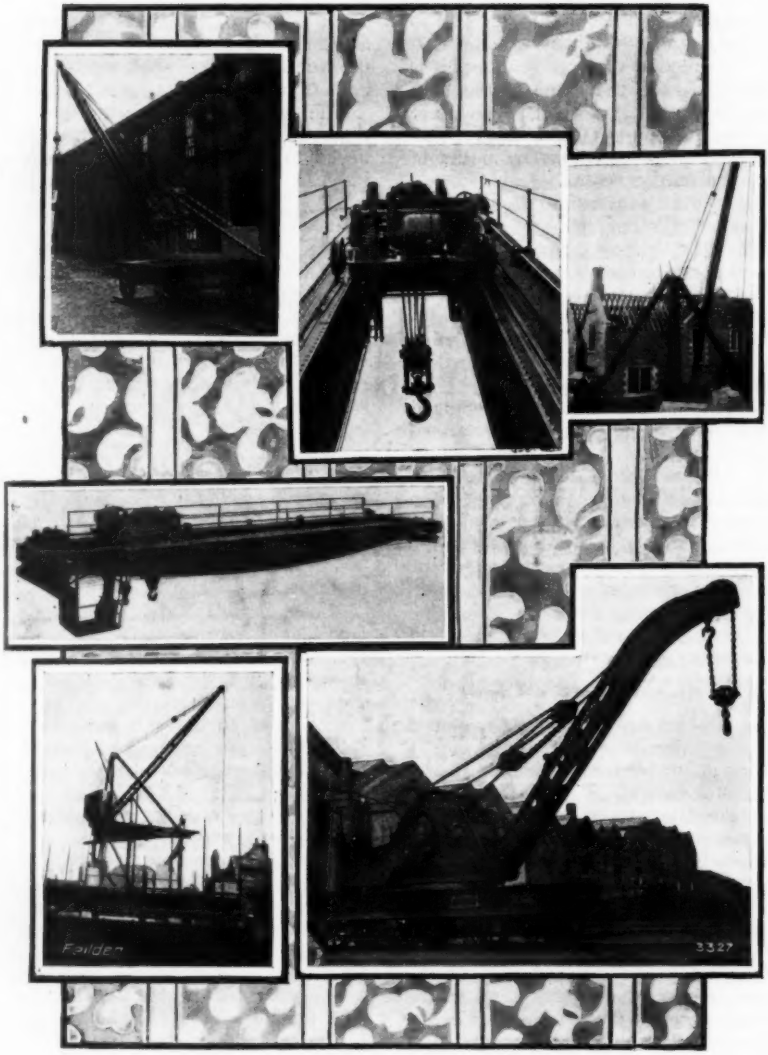
5

1

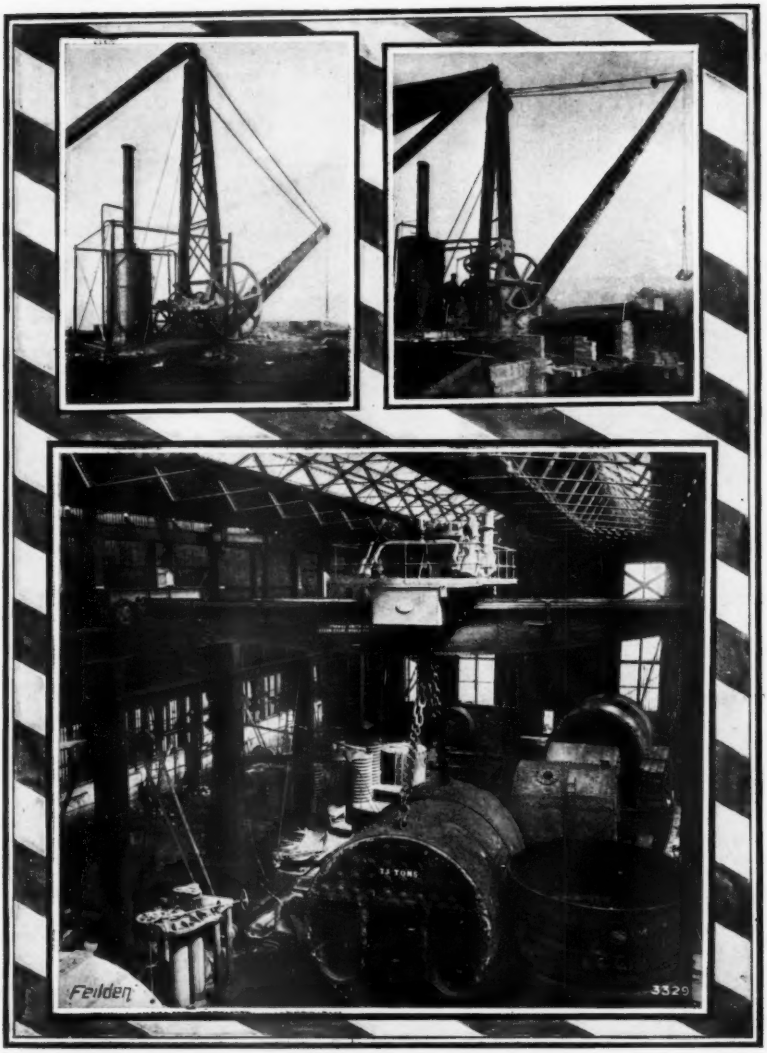
16

4

9



MODERN CRANE CONSTRUCTION: FIGS. 1, 4, 5, 9, 16, 17.



MODERN CRANE CONSTRUCTION: FIGS. 2, 3, 12.

steam derrick crane, with 70-ft. jib, in H form.

Another type of crane closely akin to the steam derrick crane is the

Steam Quarry Crane.

This type has a short jib, from 20 to 30 ft. long, and has no derricking motion. The body is long in order that the jib may swing under it, and make a complete circle, and that the crane may lift at any point. The guys are very long, say 60 to 70 feet, and the ends are built into a raised stack of stone, no sleeper guys being used. A single-cylinder engine will do the work required up to 10 tons, but in cranes of greater lifting capacity it is advisable to have two cylinders.

A 20-ton quarry crane would require a pair of 8-in. cylinder engines, and a boiler pressure of 80 lbs. The uprights would be a pair of 18 × 7 H-section steel girders, firmly braced with wrought-iron or steel cross stays, and prepared to receive gearing, top and bottom castings. The winding wheel would be 8 ft. diameter, 7 ins. wide, keyed on to a steel shaft 7 ins. diameter. The external wheel (for swivelling motion) would be 8 ft. diameter, made in sections securely bolted together and fitted to the foundation casting. The jib would be constructed of two 16 × 6 ins. steel joists, securely braced with steel cross stays, fitted with steel head and sheave, and foot castings. The jib rods, sloping from the body top to the jib head, should be of best wrought iron, $2\frac{1}{4}$ ins. diameter.

Fig. 3 represents a 20-ton steam quarry crane, in which the jib is of steel, 30 ft. long. The illustration shows framing for house to cover the boiler and platform.

Electric Derrick Crane.

This type of crane has come rapidly to the fore lately, as the initial cost is less than that of a steam derrick crane, whilst the working efficiency is greater, and the cost of power much less. A further advantage is that of being able to start at a moment's notice, without attention such as is necessary in the case of a steam derrick.

In practice it has been found that one shunt-wound non-reversible motor, of the enclosed or protected type, running constantly whilst the crane is in use, gives the best results.

The usual speed of the motor is from 800 to 900 revolutions per minute, and in order to transmit the power to the mainshaft, and to reduce the speed to about 200 revolutions on the latter, broad friction pulleys and cut spur gearing are used. The motor is securely fixed on the platform, the shaft being lengthened to receive the motor friction pulley.

The other friction pulleys and cut gearing are carried in a swing frame, bearing on the first-motion shaft, and operated by vertical screw and hand lever. The motor friction pulley drives on to two larger flat frictions, each of the latter having keyed to it a small cut gear wheel, which engages into a spur wheel on the mainshaft.

By means of the vertical screw and hand lever, either of the larger frictions may be put into motion, and by a second spur wheel, placed between the larger friction and spur wheel on mainshaft, the reversing motion is attained. Therefore, when the top friction is engaged with the extra spur wheel between it and the spur wheel on mainshaft, the motion is forward, and when the bottom friction is engaged the motion is backward, the motor running free when the pulley is midway between the two frictions.

The swivelling motion is worked from the mainshaft, by means of bevel gearing and double male and female gearing. Although the direction of the mainshaft may be altered by the lever as before described, it is sometimes necessary to swivel the load when it is being hoisted or lowered by the crane. The derricking motion may be held either by clutch, by catch and catch-wheel, or by worm and worm-wheel, as in the steam crane. The electric derrick crane is easily handled, and any intelligent workman can be instructed in its control in a short time.

Fig. 4 is the photo of a 4-ton electric derrick crane, with jib in H form 50 ft. long, and erected on a staging 60 ft. from ground level. The cost of power for

working this crane for one week is only about 4*s*., with energy at 1½*d*. per unit.

Portable Hand Crane.

A portable crane is one in which the complete crane is mounted on a bogie or carriage fitted with wheels for travelling either on a road or on a rail track.

The centre pillar, which carries the revolving superstructure, fits into a star casting in carriage, and is machined on the working surfaces to allow of easy slewing.

The weight of the jib and part of the load is counterbalanced by means of a balance box, generally made of cast iron, and so designed that any weight may be put into it, according to the weights to be lifted. If made solid, the balance box is fitted with hand wheel and screw, so that its position may be regulated, nearer to, or further away from, the centre of the crane, as required by the load to be moved, thus taking some of the strain from the centre pillar. Thus, with a full load the balance box must be at the extreme edge of the tail piece, but if placed there for light loads it would probably overbalance.

When used on a metal track, a portable crane is usually fitted with a set of dogs, or rail clips, to hold on to the metals when necessary for increasing the stability of the crane.

A wood platform is placed on the top of the carriage, for the workmen manipulating the crane; and slewing gear can also be fitted if desired.

In this type of crane it is impossible to have a jib exceeding 25 to 30 ft. in length, unless the gauge is made greater than 6 ft., and unless a very heavy carriage is used to counterbalance the leverage of the jib.

A form of this crane, largely used for breakdowns on railways, is provided with a steel jib, hooked over at the top, so as to enable heavy loads to be lifted close up to the jib.

Fig. 5 is from a photograph of the 20-cwt. size, with travelling wheels for 4-ft. 8½-in. gauge, derricking motion, and wire ropes.

Fig. 6 shows the 3-ton size, with 20-ft. jib, and wheels for road travelling.

Steam Locomotive Travelling Cranes.

This type of crane is extensively used on dock wharves, in stone quarries, on railway works, and in engineers' yards. For many purposes it is the most useful crane that can be employed. It can readily be moved by its own steam to any point where required on a job, and thus may do the lifting required at several places, each 50 or 100 yds. apart. In trench work, whilst the skip is being filled at one point, the loco. crane will travel to the next point of operation, lift and empty the skip there, and pass on to the next. Again, this crane can lift its load, and travel with it suspended to any point where it may be required.

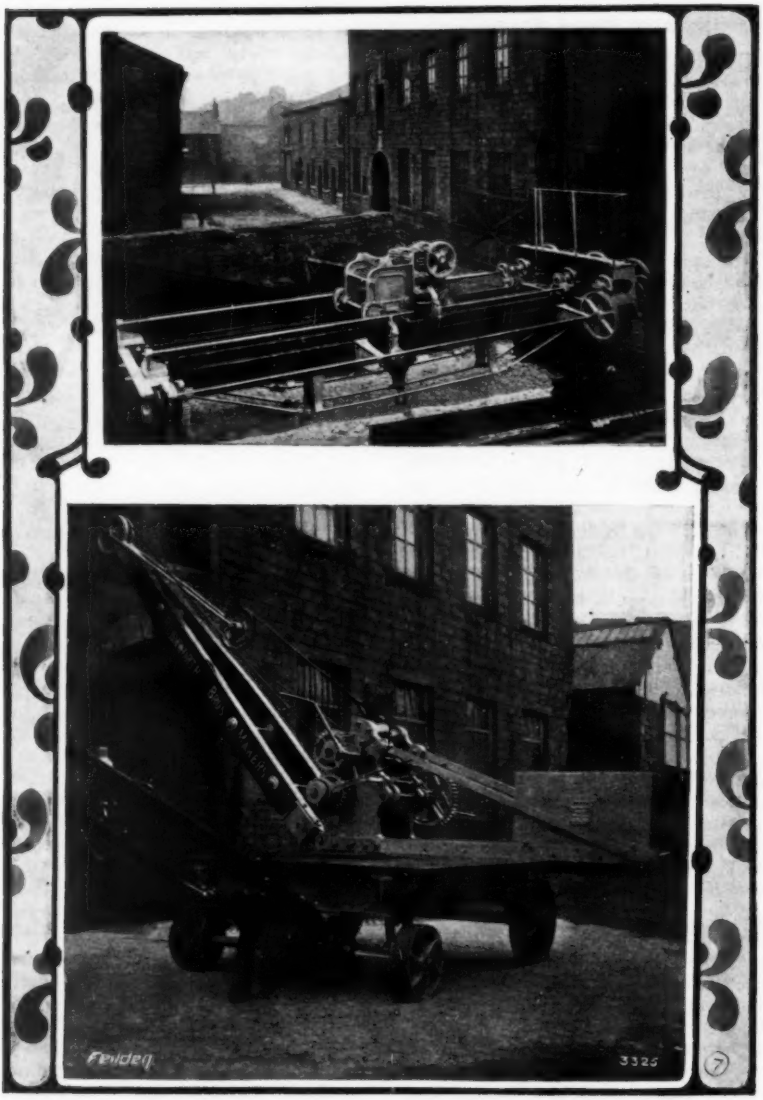
A fixed steam derrick crane with a 60-ft. jib would not be able to lift its load at a radius of more than 42 ft., and then only for three-quarters of the circle. The loco. crane, which is self-contained, makes a complete circle, and is enabled to lift at any point. Thus, with a jib 30 ft. long, it would be able to lift at a radius up to 21 ft. all the way round.

The jib is counterbalanced by the weight of the boiler and water tank, and the weight to be lifted comes upon the upright pillar, or centre of crane.

For cranes up to 3 tons lifting capacity with short jibs the ordinary railway gauge of 4 ft. 8½ ins. is usually adopted, but in larger sizes the gauges are increased to 6 ft. for a 5-ton size with 30-ft. jib, or with 35-ft. jib to 7 ft., and for a 10-ton size to 11 ft. These increases are necessary to give greater solidity for the larger weights, and to prevent the crane from overturning.

The engines are bolted in a vertical position outside the crab sides. They are generally of the two-cylinder type, the cylinders ranging from 4 ins. to 9 ins. diameter, and the stroke from 8 ins. to 14 ins. Link-motion is provided for starting or reversing the engines in any position. The hoisting motion is single, double, and treble purchase, taken from crankshaft by spur gearing, and controlled by clutch and lever keyed to shaft.

The revolving motion is worked by means of spur and mitre wheels, geared up from the crankshaft to the main internal



11

6

MODERN CRANE CONSTRUCTION: FIGS. 6 AND 11.

wheel on the frame, and worked by means of a double friction cone, so that the crane can be radiated in either direction without stopping or reversing the engines. This motion is controlled by means of a screw lever, with hand wheel.

The jib adjusting motion is worked by means of spur and worm wheels, with wrought iron worm, geared up from the crankshaft, and the derricking motion is controlled by means of clutch and lever.

To prevent the jib from running down, the crab is fitted with safety clip brake. The winding wheel has a powerful friction brake, operated by a foot lever that can be applied and secured in any position.

The propelling motion consists of spur and bevel wheels, geared up from the crankshaft to the travelling axles, and controlled by clutch and lever.

The whole superstructure radiates on a centre pillar, truly turned to fit into the base-plate, and securely fixed to the frame. The gearing is so arranged that the crane may be travelling, winding, slewing, and derricking either together or separately.

The jib is of wrought iron or steel, composed of channels or angles well braced and riveted together. There are many different designs for this type of crane, to suit the special circumstances under which an individual crane has to work.

If the crane is intended to be used as a shunting engine as well as to do its own work, it is built somewhat on the lines of a locomotive. The wheels are coupled, and the wheelbase is kept as short as possible, to enable the crane to work round short curves, so common in works and sidings. In graving docks it is sometimes necessary to have a crane which will lift, revolve, and transport a heavy load at a long radius, whilst standing independently on its own wheels. A crane of this description, to lift, say, 20 tons at a radius of 47 ft., is mounted on four pairs of wheels on a 12-ft. gauge. The jib, instead of being secured to the crab top, as in the ordinary crane, is arranged with special diagonal bracing to take the strain. Quadruple purchase is needed for the adjustment of the jib. The weight of this crane, with the necessary ballast, is about 130 tons.

Fig. 7 is a view of a 5-ton shunting steam crane. The carriage is of built-up steel, strongly riveted together, and the travelling wheels are inside. The crane is fitted with spring buffers and the usual railway couplings.

Fig. 8* shows a 10-ton crane of similar design. This crane has a very long jib, and the carriage, built up of steel in box form, is mounted on three pairs of travelling wheels. The gauge is 4 ft. $8\frac{1}{2}$ ins., and the crane lifts its maximum load at a radius of 38 ft. The special diagonal bracing, for taking the strain of the jib, mentioned in connection with cranes for use in graving docks, is shown in this illustration.

Fig. 9 illustrates a 15-ton steam breakdown crane, made by Messrs. Cowans, Sheldon & Co., of Carlisle, for permanent-way use, the curved jib being intended to afford greater headway. The crane cheeks, boiler, jib, carriage framing, pinions, pathway, pathway rollers, and central pillar are all of steel. Owing to the great length of the crane, and in order to distribute its weight over a larger area of permanent way, the carriage is mounted on four pairs of wheels, the two pairs of leading wheels being on a bogie.

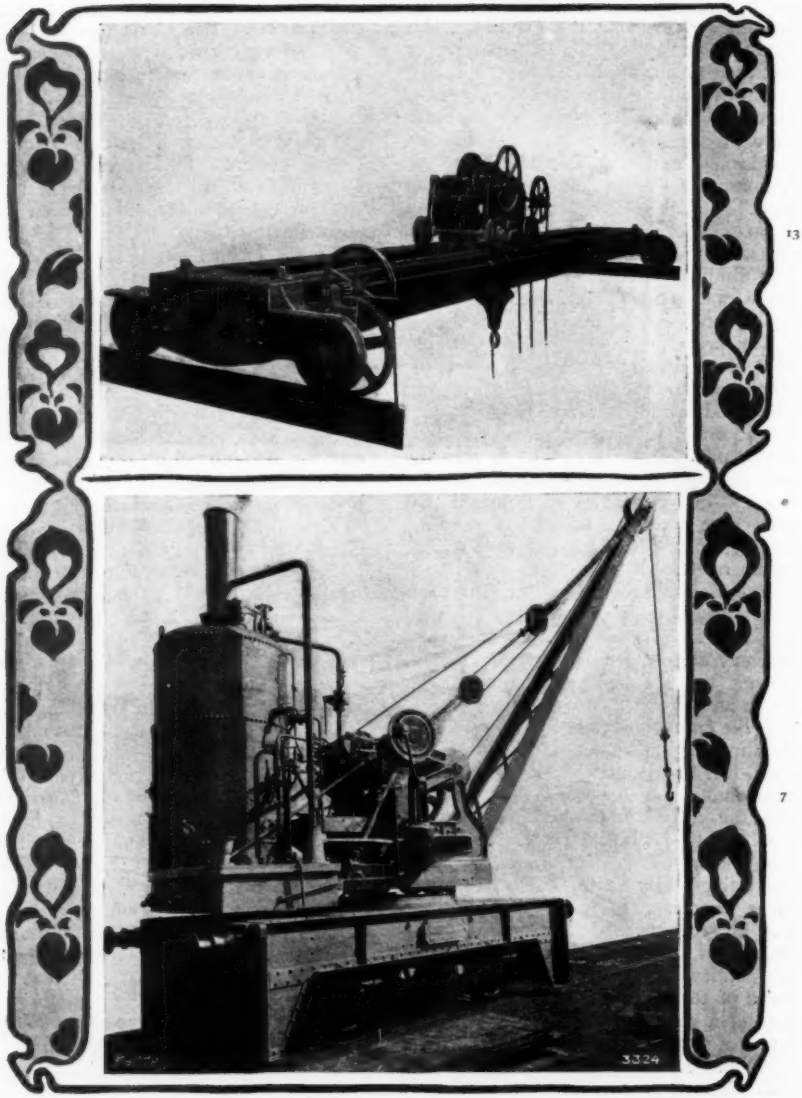
Screws are fixed over the springs, to adjust the platform when working on an incline or curve, and also to take the weight off the springs when the load is being lifted. Relieving gear, for taking the strain off the pillar and locking the crane in position when travelling, is fitted to the carriage. The total weight of this crane is about 55 tons.

Fig. 10* shows the same crane with match wagon and in running order. It is the finest crane for use in cases of emergency when awkward weights have to be moved with speed and efficiency.

Electric Locomotive Travelling Crane.

If we apply electricity as the motive power, in place of steam, to the foregoing type, we get the electric locomotive crane.

* This figure will appear in the next instalment.



MODERN CRANE CONSTRUCTION: FIGS. 7 AND 13.

Such a crane will perform exactly the same duties as the steam locomotive crane, but at a much more economical rate, as the supply of current is stopped when the machine is not actually working, while in the other steam must be kept up all day long, even if only one lift per hour is required. At the same time, the electric crane is not quite so adaptable as the steam crane, because proper equipment is required for the conveyance of current to the motor throughout the length of the track to be traversed.

Current is supplied by means of a contact rail running along the centre of the track. The contact rail, fixed slightly above the level of the travelling rails, and supported on sleepers by means of glass insulators, is boxed in for its whole length, a slot being left at the top of the casing through which passes the slipper for picking up electric current. A single motor only is required, and that of the shunt-wound non-reversible type, completely enclosed. This is fixed to the bottom of the crab, and the cable from slipper comes up through the centre pillar and to the terminals of the motor. Motion is transmitted to the main-shaft of the crane by means of friction pulleys and spur gearing, the reversing motion being attained by an extra spur-wheel in one portion of the gearing.

Two of the friction pulleys and the spur-wheels are carried in a swing frame, operated by means of vertical screw and hand lever. The lever permits either of the friction pulleys to be put into contact with the pulley on motor shaft, thus giving motion in the required direction; or the friction pulleys may be placed so that the motor pulley is midway between the two, thus allowing the motor to run free. The winding, travelling, revolving, and jib-adjusting motions are like those of the steam locomotive crane.

There is considerable difference of opinion as to the superiority of a shunt-wound motor, running constantly in one direction, over a series-wound motor with reversing controller.

With the former it is claimed that, by taking advantage of the motor being already in motion, the gearing can be started more rapidly, thus saving time, whilst the direction can be reversed almost instantly. Again, having a constant speed, the operator knows exactly the speed at which the load will be lifted by using single, double, or treble purchase. Against this it has been proved that if the motor runs at a high speed it causes the load to swing, and the necessary control of it is somewhat reduced.

If the series type with reversing controller be employed, power can be transmitted direct to the main-shaft by means of spur gearing, and the fast and slow gears are thereby rendered unnecessary. In this type the speed increases with the reduction of the load; it starts gradually from a state of rest, and quickly attains the maximum.

Therefore, by using the series motor the motions are put gently into gear, the main portion of the work is done quickly, and speed is rapidly reduced at the end of the lift or travel.

The crane is fitted with an electro-magnetic brake, which is automatically released immediately current is switched off from the motor. If from any cause the current should fail whilst a load is on the crane, the brake immediately takes control of the load.

The jib should be balanced by means of a balance box sliding along two rails, as in the hand portable crane.

The electric locomotive crane has not as yet made much headway, but in the near future we may see it superseding the steam locomotive crane on account of its lower initial cost and economy in working.

(To be concluded.)

High-Speed Engines.

Balancing.

By J. H. DALES, A.M.Inst.C.E.

(Continued from page 203.)

❀ ❀ ❀

THERE are two principal disturbing forces which cause vibrations in unbalanced reciprocating engines. First the reciprocating parts which are attached to the crank, and second, the centrifugal effects of the crank and connecting-rod weights. Both of these are present in high-speed engines in a very much exaggerated form as compared with slow-speed engines. It has been shewn in earlier articles that, with regard to the first item, the inertia of the piston line is often greater than the steam pressure on the piston area. The principal directions of these forces are in that of the piston line, and transversely to that, at the crank-shaft centre. The crank and parts which have a purely circular motion are easily provided for by balance weights, with similar moments acting in opposite directions, but the reciprocating parts and those which have a compound motion between that of the piston and of the crank, are not so easily disposed of. More especially is this the case where relatively short connecting-rods are used, which make the inertia to the out-stroke to differ from that of the in-stroke. The strokes could only be balanced by duplicate sets of parts on opposite centres, and to be without couples on the same centre lines, which would be impossible. The nearest thing to a balance in such circumstances would be two light lines on one side of the shaft, with one heavy line equal to the combined weights of the two light ones on the opposite side, and between the two light lines, or some equivalent. Such provisions, however, can seldom if ever be made, and the problem before the builder is how to make the best partial provision. Very great forces are generated (as will be shown later) by the reciprocating and revolving parts of an engine when running at high speed, and whilst these may be internally balanced to some extent by opposing forces, much depends upon the rigidity of the frame, as to what extent the remaining unbalanced forces take effect in producing secondary vibrations in it, which may be transmitted to foundations or connections. If absolute rigidity of the frame could be ensured with, at the same time, a practical absence of slack in the bearings, the counter effect of the frame to the "motion," or moving parts, would be in the ratio of the respective weights; but as no such thing as absolute rigidity of frame can be had, secondary motions are, to some extent, set up in the same. The "periods" of the "motion," and the natural vibrations of the frame, have also much to do with intermittent aggravations of the secondary vibrations. Heavy and rigid frames and bed-plates, which have a high rate of natural vibration, and at the same time a high ratio of difference of weight to the "motion," are therefore calculated to prevent and reduce the formation of vibratory actions, leaving less to be dealt with by the foundations, which are usually composed of, or connected with, more elastic material than that of the frame.*

A casual investigation of the amount of the forces at work will perhaps best illustrate the necessity and importance of balancing arrangements. The illustrations will in the first place be confined to the features of a single piston line.

* A prevalent notion that unbalanced forces make any material detrimental difference to the comparatively enormous bearings of this class of engine, especially in connection with the very rigid frames in which they are mounted, is, in the opinion of the writer, not well founded; but that, on the contrary, the action of such forces is rather likely to assist in the distribution of the copious lubrication which is provided.

Referring to Fig. 1, an inertia diagram is shown of a piston line of 250 lbs. weight, 8-in. stroke, and 450 revolutions per minute, with a connecting rod of five-crank lengths. The weight taken does not include the effective weight of the unbalanced crank-pin and cheeks, which at the crank centre is equal to 42 lbs. The total weight of the connecting rod is 112 lbs., 70 lbs. of which take effect on the crank centre for the transverse effect of the crank (and portion of connecting rod) at half-stroke (approximate). The remaining 42 lbs. weight of connecting rod is apportioned to the cross-head or gudgeon pin.

The inertia of the piston line at the commencement of the outstroke is as 6 to 4 of that of the commencement of the instroke, and these are respectively 6,816 lbs. and 4,544 lbs. These are the figures without any reference to the crank, which has a centrifugal force of 2,540 lbs. transversely at half-stroke (approximate), when reckoned with 70 lbs. of the connecting rod added, and in the piston line a centrifugal force of 954 lbs., when reckoned without the portion (70 lbs.) of the rod, the whole of the rod for inertia being taken in the piston line diagram. On a line *A B* (Fig. 3) an ordinate may be erected (*C D*) to represent the inertia of the commencement of the outstroke (the figure is to a scale of 4,000 lbs. per inch), or 6,816 lbs., which would be the total vertical lift under the cylinder lid, as the steam overcomes the inertia of the piston line to the speed, if the steam had sufficient force for the purpose; or, if not, that inertia would take effect combinedly on the crank and cylinder lid — in any case producing on the engine frame an effect of 6,116 lbs. in the direction of the piston line. Added to this would be the centrifugal force of the crank in the same direction (954 lbs.), making a total lift on the frame at the commencement of the outstroke of 7,770 lbs. In the end of the second half of the stroke the momentum of the piston line, represented by *C E*, takes effect on the frame by a pressure on the same of 4,544 lbs. and 954 lbs. centrifugal force of crank, which amounts to 5,498 lbs. Transversely at half-stroke (approximate) the centrifugal force of the crank and portion of the rod acting at the crank centre amounts to 2,540 lbs., which also, being an alternate action rocking the engine frame, has a total difference of effect on the frame or bed of 5,080 lbs., at the crank-shaft centre. These quantities are striking when it is remembered that they belong to a very small engine, weighing, without foundation plate, only some 35 cwts, or with that plate about 50 cwts.

The inertia of the engine bed and rigid connections would, of course, counteract against these disturbing forces, in the ratio of the respective weights of the bed and "motion," and the net result would be a motion of the bed due to the elasticity of the same against the unbalanced moving weights. Probably the greatly increased relative vibration of high-speed engine frames is due to the natural vibration of the frame produced by any single impulse of unbalanced force, not having time to subside between the impulses, which would thus have a circulative effect. The benefit of heavy foundations is obtained only to the extent of the tightening of the bolts, and the elastic tension of the same. This stands to reason.

In order to represent graphically the vertical and transverse disturbing forces in a general way, ellipses are developed on lines *A B*, and *D E*, the length of which represents the total minus and plus forces of the out- and in-strokes, and the width, the centrifugal force of the crank group.

Fig. 3 shows first a circle, around the intersection (shaft centre) of lines *A B* and *D E*, which, by its radius to the scale mentioned (4,000 lbs. per in.), represents the centrifugal force (945 lbs.) of the crank only, while half the major axis of the same ellipse which is drawn upon *A B* represents also to scale the transverse centrifugal force of the crank and portion of connecting rod, or 2,540 lbs. The crank path is represented by the circle so marked, and is used for the purpose of identifying the various corresponding positions in the crank circle of the inertia ordinates. The large ellipse, which is constructed with the 6,816 lbs. + (954 ×

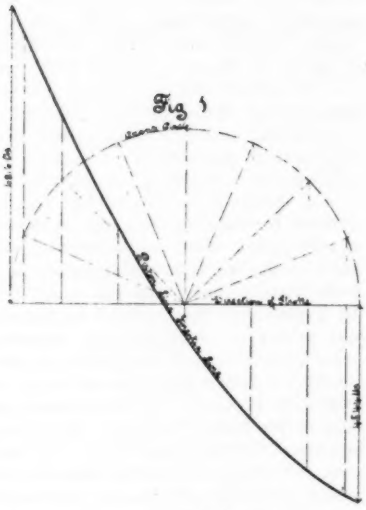


Fig. 1

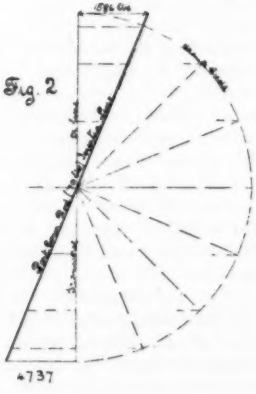


Fig. 2

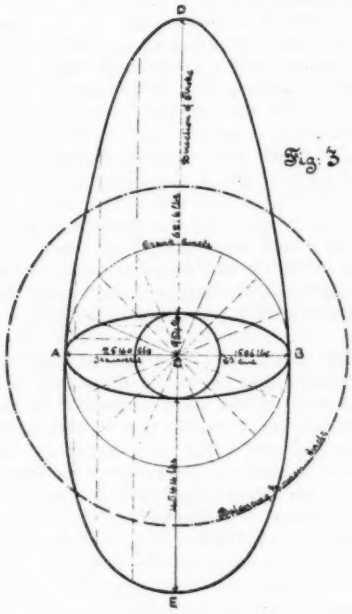


Fig. 3

2) + 4544 lbs. as the major axis and the 2,540 lbs. as the minor, generally represents the forces concerned, the form of the curve being developed by ordinates to the line *C D* (which are corrected for the inclination of the connecting rod), which are taken from the inertia ordinates of Fig. 1. No account is taken of the effect of the weight of the small end of the connecting rod on the crosshead in order to simplify the figure.

In considering the balancing of an engine of the class referred to it is usually sufficient to know the maximum forces in the two directions of the piston line and transversly to that through the crank-shaft centre. These are useful to show the excess forces over and above the possible balances, which latter are simply matters of providing suitable moments, the excesses shewing the extent to which foundation weights must be provided. An endeavour is here being made to illustrate the subject (which in its entirety is one of considerable complexity) in the simplest possible way, rather than to exhaust all its features, a graphic shewing often suggesting a remedy. It is clear that closely approximate transverse balances to the crank and portion of the rod, can easily be made by tail pieces on the crank-cheeks, which is by far the best method (though expensive if solid), but that, except by a double similar

piston line on opposite centres, the reciprocating parts could not be balanced correctly, and further that double-cylinder piston lines on the same side of the crank-shaft centre are not balanced by each other except when in a state of rest; but as that condition is no part of the consideration, it may be said that they are not balanced, and that the shorter the connecting rod the more they will be out; in short, that an in-stroke cannot balance an out-stroke, and *vice versâ*. In the case illustrated they would be $\frac{1}{3}$ out of balance alternately.

Referring again to Fig. 2 a large circle is shown, marked balancing moments circle, which represents the moments of balance weights or tail pieces to the crank, and are such as can be usually provided in an ordinary crank-well. The centrifugal force of the crank and rod transversely is about half "over-balanced" by these moments, which is equivalent to lightening the crank and attachments by about half their effective weight, while in the example dealt with the end of the out-stroke (momentum) is balanced to the extent of $\frac{5}{7}$ (about), and the end of the in stroke to about one-half. This means that against an unbalanced engine, one so provided would make, with a given limiting vibrating force, a speed equal inversely to the square roots of the excess of the partially balanced force and the unbalanced force (these being about 4 to 10), and the square roots as 2 to 3·18; so that, whilst a partially balanced engine (to example) would run 450 revolutions per minute with a given vibration or extent of vibration, the same engine would, if unbalanced, run only 283 revolutions with the same result, the balancing adding practically 37 per cent. to the usefulness of the engine, and the maximum unbalanced disturbing forces being reduced 60 per cent.

The centre of the shaft, on which the transverse forces of the crank, etc., take effect, is usually very low in the frame, and the spread of the bed-plate reduces the force of the moments at the limits of the leverage, so that such an overbalanced arrangement has a much better general effect than a close approximation to an exact balance of the crank and connections only.

A glance at Fig. 2 will show that the strong dotted circle (which represents by its radius the moments of the balance-weights), while showing an excess transversely, and a shortage of force longitudinally, has four points in crossing the outline of the ellipse where the balance is exact, and points to a fact that, whatever the form of the latter figure, such a coincidence must occur four times in the revolution.

The uninitiated must first of all grasp the idea that the inertia and momentum of the reciprocating parts constitute free forces, which act upon the frame of an engine exactly in the same way as they would if they were applied outside, and are in no degree neutralised as forces by the connections of the parts to the frame, except by the inertia of the latter.

Considering the actual effect on a dead weight foundation, the work done in the acceleration of the piston line taken on the out-stroke is about a mean of 3,408 lbs. through $3\frac{1}{2}$ ins., or 11,928 inch-pounds per stroke, that is to say, unbalanced the inertia of the piston line would lift about 5 tons 1 in., or the equivalent work in the time of $\frac{7}{16}$ of a stroke. The unbalanced piston-line to the whole weight of the engine and bed plate in the case in point is about $\frac{1}{20}$, so that if the engine and plate stood on springs of a stiffness of $3\frac{1}{2}$ ins. to 50 cwts. the engine would be lifted ·175 inch, while 25 tons would be lifted ·0175 inch, and so on. Assuming a concrete bed 9 ft. square and $4\frac{1}{2}$ ft. thick, the lifting motion could be reduced to $\frac{1}{1000}$ of an inch by supporting the mass on springs of a stiffness of 24·5 tons per inch; the whole mass of the engine and bed being taken at 25 tons; balanced engines, as is seen by the diagram, would vibrate about half this amount.

The whole connected mass of engine and bed should be enormously greater than that of the disturbing element, and the ground connections made with a medium with no audible rate of vibration. Heavy holding-down bolts, tightened to an extension equal to the weight of the foundation, it is evident, would be

necessary to get the full benefit of the latter. Sympathetic and consequently cumulative vibrations must be avoided.

In the matter of couples, as in double or triple engines, these will be of much less effect if the single lines are partially balanced.

It has been proved in practice that a knock which produces high-rate vibrations can be eliminated by suitable provisions, and, by balancing and isolation, frame vibrations can generally be reduced to inconsiderable effects.

Partially overbalanced to about the extent named, 6-in. stroke single-cylinder engines will run 600 revolutions per minute with very little transmitted vibration, even when the reciprocating parts are relatively heavy when considered in reference to the weight of the engine

(To be continued.)

British and American Railroad Practice.

For the last year or two, and more especially during the past few months, there has been "a sort of warfare" going on against the methods adopted by those responsible for the management of British railways. All manner of critics, some qualified and others unqualified, have been expressing their opinions in the press and at meetings of railway companies, finding a congenial occupation in comparing British methods with American methods, much to the disadvantage of the former. We need not complain of such criticism, for no one denies that there is room for improvement on many of our railways; but if it is to be effective it must be well informed, and that cannot be said to be always the case here. It is therefore matter for congratulation that the President of the Board of Trade should have sent the Chief Inspecting Officer of Railways on a trip to America, to see for himself the actual state of affairs there, and to present an official report to the Department on his observations. Here at least we may expect to find useful criticisms and suggestions, as Lieut.-Col. Yorke's experience of railway affairs in this country makes him in every way a competent critic. We recommend all who are interested in railway affairs to read for themselves this report,* and we hope indeed that our readers may all be induced to study it, and learn something of the all-important question of transport of passengers and goods-traffic.

The attention of this government official was chiefly directed to the construction and equipment of:

1. Steam railroads.
2. Surface lines or tramways, subways, and elevated railways.
3. High-speed electric inter-urban railways;

and each of these three branches of modern railway enterprise is discussed at some length in his report. It is not possible for us in the space at our disposal to go into all the different matters that have received his attention, but it may be useful to deal with some of the more prominent points, especially those around which the controversy in this country has centred.

I.—Steam Railroads.

In the construction of the permanent way American practice is somewhat different from that followed in this country. On British lines the custom is to use bull-headed rails resting in iron chairs, whereas the Americans use the T-rail resting directly on the sleepers, to which it is fixed by ordinary spikes. There is thus on British lines a lateral support to the rails which is wanting on American lines, although on curves it is of the greatest value. In America it has been found necessary, in the absence of chairs, to give this lateral support on curves by using rail braces. The superficial dimensions of American sleepers are smaller than those of English sleepers, so that there is an advantage again for the English line in that there is a greater bearing-surface per sleeper as between the sleepers and ballast: but this is to some extent, but not wholly, compensated by the greater number of sleepers used on American lines. There are usually fourteen or sixteen to a 30-ft. length of rail, while English practice gives twelve; and for such length the actual total bearing-areas are respectively 74·6 or 85·3 sq. ft. for America and 90 sq. ft. for England. The advantage of English practice is again increased by the greater bearing-area of the English rail on the ties or sleepers. For the American permanent way it is claimed that it is cheaper to maintain and easier to lay; but on the first of these points Col. Yorke

* "Report on a Visit to America." By Lieut.-Col. H. A. Yorke, R.E., Chief Inspecting Officer of Railways. Eyre & Spottiswoode, East Harding Street, Fleet Street, E.C. [Cd. 1466.] Price 5d.

expresses the opinion that the English system must give the best results. One point in American practice is the custom of making the rails break joint, so that the weak spot on one side of the track is supported by the continuous rail on the other. The English practice is to have the rail joints opposite each other, and in this matter Col. Yorke thinks that something might be gained by copying America. But, on the other hand, the apparent objection to the English practice is overcome by the fact that at joints the sleepers are placed closer together, the object being to maintain the elasticity of the track uniform throughout. In discussing the construction of the permanent way in the two countries it is important to remember that American sleepers are of hard wood, such as oak, and this would seem to be necessary for the American system of fixing the rails by spikes; so that if that system were to be adopted for this country the extra cost of the sleepers would have to be taken into account, and would probably outweigh any economy that might otherwise be obtained.

The arrangements for signalling—block system, automatic signalling, and so on—appear to have received a good deal of attention from Col. Yorke; but as it is clear that no system yet adopted in America shows an out-and-out superiority over those in use in this country in securing absolute safety of operation, we need not give more than passing notice to this subject. In many respects it is clear that American railway companies are willing to run risks which would not be allowed in England. In block-working "two or more trains are constantly permitted to be in the same section at the same time, and trains are allowed under certain conditions to travel in either direction on either track, even where the lines are doubled or quadrupled." Probably everyone will agree with Col. Yorke that "such a mode of working must be dangerous," and we should have been glad if he had included in his report some statistics of the accidents and loss of life from collisions in America for comparison with returns for this country. Some of our lines are now experimenting with automatic signals, and the results will be awaited with interest; but so far as this report deals with American automatic systems, we do not think any useful lessons for ourselves are to be obtained from it, except that these systems are not only far from perfect, but are in many respects unsuitable for the conditions prevailing in this country. "Automatic signalling," says Col. Yorke, "does not of itself introduce greater safety of operation. It is merely a labour-saving device. No doubt it eliminates the risks due to mistakes of signalmen, but it introduces other risks peculiar to itself, due either to inefficient maintenance, to failure of the mechanism, to weather, and to accidents of various sorts." The weather conditions in this country must be specially remembered in devising automatic systems for use here, as the prevalence of fogs in winter introduces difficulties which do not occur in America, where fogs are rare. We believe, therefore, that Col. Yorke is right in looking to the experiments now being made on English lines rather than to American experience to determine the applicability of automatic signalling to our main lines.

The difference between the rolling stock commonly in use in England and that used in America is one that appeals to the eye, and for that reason much of the controversy on the conservatism of English railway companies has centred round this subject. In the first place the American locomotives are much larger, standing, in some cases, 16 ft. high above rail level, and in many more 14 ft. 6 ins. and 15 ft. The extra power of these engines is no doubt a great advantage, but before jumping to the conclusion that similar engines should be used here, one must study the history of railway construction in the two countries. From the earliest days of railways in England, tunnels and over-bridges have been common, and the height of the roof of such structures above rail-level is, as a rule, only a few inches over 14 ft. Consequently the height of engines and cars is strictly limited, as the rolling stock must adapt itself to the line. But in America the position is different, for, as Col. Yorke points out, tunnels and

bridges were almost unknown on early American railways, and although these are now being constructed in large numbers, they are made to suit the rolling stock, and have a height of 18 ft. above rail-level. Thus what is possible in America is impossible in England. Then with regard to the large American freight cars, about which so much has been said and written, the conditions regulating cost of transport are too often forgotten, and one of the most important parts of the report under consideration is that in which Col. Yorke tries to clear away the misapprehension that prevails on this subject. The American cars have a carrying capacity varying from 30 to 50 tons (of 2,000 lbs.), with a "tare" weight from 15 to 20 tons, and all are carried on bogies, usually eight wheels to a car. Take, then, a 50 ton car. When loaded, it has a total weight of 70 tons, that is, 17½ tons per axle. The cost of transportation depends upon the carrying capacity of the car in relation to its weight, and will therefore remain unchanged if we replace the 50-ton bogie car by two four-wheeled cars, each of 25 tons capacity, and a tare of 10 tons. It should be remembered also that in taking the 50-ton car, we are taking one which gives better results than the more common car in general use, running from 30 to 40 tons, as in these the tare weight is not correspondingly reduced, but runs from 16 to 18 tons. But we have also to consider the suitability or otherwise of our lines for cars of such large dimensions; and here we are met by most serious difficulties. To adopt such cars generally would practically necessitate the complete reconstruction of most of our sidings, goods sheds, weigh-bridges, turn-tables, and so on, as these are, as a rule, quite unsuitable for such large wagons. The cost of such reconstruction would be enormous, and shareholders should remember this when criticising the management of the lines in which they are interested. At least two of our great railway companies are now using four-wheeled cars with a capacity of 20 tons, and a tare of about 8 tons, which gives the same proportion of paying-load to dead-load as is given by the American 50-ton car, with a tare of 20 tons; and such an improvement, increasing the carrying capacity of the wagon in relation to the dead weight, while preserving the old standard form of English car, appears to be the most suitable and most desirable for the ordinary trade purposes of this country. The difficulty in the way of making even this improvement, as is pointed out by Col. Yorke, is found in the private ownership of the bulk of the wagons used on English railways, and while we agree that this could be overcome by the abolition of private ownership, we fear that Col. Yorke is too sanguine in his alternative suggestion that the Legislature might compel the private owners of wagons to adopt whatever type of wagon may be found most beneficial to the trade of the country. If competition fails to secure the general adoption of larger cars, we do not think Parliament is likely to interfere to dictate to private individuals the methods in which they shall distribute their goods to their customers. But we do not expect that legislation will be necessary, for if the railways show the example and secure good results, we feel sure that the private traders of this country are sufficiently alive to their own interests to adopt any improvement that will lead to an increase of profits.

The imperfection found in the automatic signals now in use in America is also a feature of the automatic couplings and air-brakes for use on steep gradients. The law of America now demands the use of automatic couplings and air-brakes on all freight cars engaged in inter-State commerce; but it is clear, from the Inter-State Commerce Commission Report of 1902, which is quoted by Col. Yorke, that the problem of safely working heavy freight trains down steep grades is as yet only partially solved. For the description of the actual American practice in this matter, and the objections made against it, we must refer our readers to Col. Yorke's report.

The discussion of steam railroads ends with a few interesting notes on the American organisation in railway service, by which it appears that in the choice and training of railway servants, and in the opportunities

for promotion from the lowest to the highest grade, the American companies are much further advanced than our own. Examinations for promotion are held from time to time, and applicants who fail to pass on the first trial must present themselves again for examination within one year. Should they fail on this second trial, they are dropped from the service altogether, to make way for more capable and progressive men. Under this scheme many of the most prominent men in the railway world of America to-day have been enabled to rise to their present positions from very inferior posts.

II.—Surface Lines, Subways, and Elevated Railways.

Col. Yorke has examined a great number of surface lines and tramways, elevated railways and subways, but there is not very much calling for special notice in these undertakings, so that his remarks on this part of his investigation are more general in character. The elevated railway is not likely to be introduced into this country, and tramway practice in America is now little different from that in England, but the financial arrangements for the construction and operation of the New York and Boston subways have an interest for this country, and more especially for London, at the present time. The arrangements in these two cities closely resemble one another, and it will be sufficient for us to take the case of New York. We cannot do better than quote Col. Yorke's remarks on this undertaking. He says :

"The cost of the New York subway is also borne by the city, the Rapid Transit Subway Construction Company being the contractors for the work, and having a lease of fifty years for operating the subway when completed. The contracting company is paid for the work in accordance with their tender, but has to pay in its turn a rental equal to the interest on the bonds issued by the city to provide the funds for the work, and in addition a sinking fund of 1 per cent., by which the principal will be redeemed within the period of the lease. The company has to provide equipment, power, and machinery, which the city is to purchase at a valuation at the end of the lease. This arrangement is similar to that under which the Chemin de fer Metropolitain of Paris is being built. The advantage of such an arrangement is that at the end of the period of the lease the railway is paid for, and becomes the property of the city free of cost. There seems no reason why some similar arrangement should not be arrived at in London."

We regret that in this matter we are unable to see eye to eye with Col. Yorke. To us there appear to be very grave objections to allowing such a body as the London County Council to become the owners of the underground railways of the metropolis. There is no doubt something attractive in the idea of the local authority becoming the owner of these undertakings "free of cost," but regard must be had to contingencies. The increase in the debt of the county of London, were such a scheme to be adopted, would be enormous. It is already much too high, but with this increase the credit of London would be most seriously impaired. Then what is to happen should these railways in the course of fifty years become suddenly, or even gradually, depreciated in value? It is easy to imagine this taking place in these days of scientific progress. And if the owner be such a body as the County Council, constantly changing in *personnel*, and liable to be dominated from time to time by men with the most hazy notions of economics or with wholly false ideas on that subject, how is the public confidence in the stability of the concern to be secured? There is much work, properly within its sphere, still remaining for the attention of the County Council To carry out that work—such as street improvements, the demolition of slums, and the general advancement of the public health—will demand the expenditure of large sums of money ; but if the enormous capital for the London underground railways has to be borrowed by this body the margin of safety for borrowing purposes will disappear altogether. And even if we were to accept the idea of municipal ownership, we should still only be able to give a qualified assent to Col. Yorke's recommendation ; for we should have to ask, What is to be done when the leases to the companies expire? Are new leases to be granted? In that case we should be more ready to assent ; but if the idea is that when that time arrives the local authority should itself undertake the

operation of the railways we must withhold our consent altogether. We do not mean to discuss that question now, for we believe that anyone who gives thought to the matter will soon see the very grave objections to such an enormous increase in the number of servants of the local authority, who would at the same time be electors of their masters.

When we pass from this question of the ownership of the railways to that of the selection of routes we find ourselves more at one with Col. Yorke. He points out that the cities of Paris, New York, and Boston have faced the problem of urban communication in a business-like fashion, have decided what they want, and have settled the routes along which transportation is to be provided; and he adds—

> "It is much to be hoped, if I may be permitted to say so, that a tribunal will be appointed before it is too late to consider the congestion of the London streets, and to propose a remedy."

Since these words were written, the Commission on London traffic has been appointed by Parliament, and every one hopes, with Col. Yorke, that the outcome will be definite proposals to meet the real needs of London, and so put an end to the haphazard fashion of laying out railways that has been the custom hitherto. The fact that it is a Parliamentary and not a Municipal Commission which is to consider this matter, serves to indicate another point bearing on the question of municipal ownership. The question of railway communication through London is one of national importance, when we take military considerations and the defence of the Metropolis into account, and even for this reason alone we would say that if railway construction in London is not to be left to private enterprise, then it must be undertaken by the government, and not by the municipal authorities.

III.—Electric (High-Speed) Inter-Urban Railways.

The final part of Col. Yorke's report is devoted to somewhat particular descriptions of the principal electric inter urban railways of the United States, and from its nature cannot be fully considered here, as it contains a mass of details. Treating it generally, however, we are, in the first place, led to remark that America is evidently much farther advanced than this country in the development of these railways. It is true that in England we have now many tramway systems or light railways connecting different towns, and in some parts of the country, as in South Lancashire, where a through route from Liverpool to Bolton has recently been opened, these undertakings cover a large tract of country; but nowhere in this country have we as yet anything exactly equivalent to the American high-speed inter-urban electric railway. Our inter-urban railways are practically tramways, lightly equipped, running on or alongside the main roads, but not in any sense high-speed railways. The American lines, on the other hand, although built sometimes on and sometimes alongside the main roads, are lines of heavy construction and heavy equipment, specially designed for high speed. In some cases they are branch lines of main railways, built originally for steam traction and now converted to electric traction; in other cases they have been specially built for operation by electricity. The returns for the principal "converted" lines, quoted by Col. Yorke, show that the change has resulted in a great increase in the annual passenger traffic, due, no doubt, to the increased speed, greater frequency of service, and reduction of fares. For example, on the Providence and Fall River Line, under the old steam *régime*, there were only 10 trains per day—no express trains—and the time taken for the 18 miles journey, with 14 stops, was 48 mins. Under the new system there are 112 electric trains per day, some express with 7 stops, taking 33 mins. for the journey, and some local with 26 stops, taking 45 mins. for the journey. These electric trains are made up of one, two, or three cars, each 40 ft. long, the motor cars having four 80 h.p. motors. The average daily traffic is 15,000 passengers (population of Providence 175,000, and of Fall River 104,000), and the fare for the whole distance is 20 cents, just half the old steam fare.

A good example of the most modern inter-urban railways specially constructed

for electric traction is the Aurora, Elgin, and Chicago Railway, which is about 60 miles long, the greater portion being double track. It is laid throughout on the company's own land (except at public road crossings), having 80-lb. steel rails in 60-ft. lengths, with 2,640 sleepers to the mile. Power is supplied from one end of the line at 26,000 volts, three-phase alternating, to six sub-stations, where conversion takes place, and current is then supplied at 600 volts direct to a third rail placed 19½ ins. outside the track. The cables, of stranded aluminium, are carried on poles alongside the track. The trains have one, two, or three cars, every axle being motor-driven, except in the three-car trains, which have one car without motors. The motor cars have each four 125-h.p. motors. The regular maximum speed is intended to be 65 miles per hour, but when the road-bed has become thoroughly consolidated experiments are to be made with speeds of 80 to 100 miles per hour. The trains are expected to attain a speed of 50 miles per hour in 25 secs., starting from rest—that is, an acceleration of 3 ft. per second per second. We believe we are right in saying that this acceleration is exceeded on the Liverpool Overhead Railway, and that 4 ft. per second per second is there obtained.

On American electric railways the multiple-unit system of control is almost invariably used, and we should have been interested to hear Col. Yorke's criticisms of the different types actually in use. This, however, we do not find in his report, perhaps because these are purely electrical details, and on that account somewhat outside his proper sphere. In his Diary, appended to the report, we do find mention of the different systems, but in the only place where anything in the nature of a comparison is made Col. Yorke does not seem to have grasped the real distinctions between the rival systems of control. He states that he examined the Westinghouse pneumatic control, and that it "seems to possess the great advantage that no high voltage electric currents are introduced into the driver's cabin or carried through the train." Now it is quite incorrect to suggest that the General Electric Co.'s system, which is the competitor with the Westinghouse system at the present time, introduces high-tension currents to the train. The current for the control is taken from the main supply—that is, usually, 500 volts—and no one speaks of that voltage as high tension. The Westinghouse system uses an auxiliary storage battery on the train; but, so far as we can see, there is nothing to prevent that being done also on the General Electric system, should it seem desirable. At the present time we believe the latter system is in much more common use in America than the former; but whatever the relative advantages be, we have a right to expect that in a Government Blue Book, if comparisons are made, they should be well informed and carefully weighed, and we fear that in this instance Col. Yorke has spoken from insufficient knowledge.

There is much that is interesting in Col. Yorke's Diary of his trip, and on matters directly connected with ordinary railway construction and equipment his remarks are very useful and instructive. He naturally saw in the course of his journey many things not connected with railways, and some of these are described in this diary; but we think he has been unwise in allowing these parts to be published. For example, the construction of steam turbines may be a novelty to Col. Yorke, but he ought to have known that the Parsons turbine has been in use in this country for many years, and that therefore a description—a bad one, by the way—of this engine, as he saw it being manufactured at the works of the American licensees, was quite uncalled for. And, again, surely it is out of place to include in a Government publication on railways a description of the Nernst lamp. No objection could be made to Col. Yorke noting in his pocket-book the details of such a mechanism for his own information, but why include it for publication in his Diary? His remarks on this subject are peculiarly inappropriate, as they almost amount to an advertisement for the American firm manufacturing the lamp. Col. Yorke goes so far as to say that

it is unfortunate we in England have to depend for the supply of these lamps on the parent company in Germany, as the American type, which cannot be placed on the English market, "seems likely to prove a great success." Could anything be more absurd? We fear that in allowing himself to deal with matters extraneous to his real mission, Col. Yorke has forgotten the old adage, *Ne sutor ultra crepidam.*

These faults, however, may be overlooked to some extent, having regard to the real merits of Col. Yorke's report on railway matters. It should do good by showing how misdirected much of the criticism of English methods has been, and by pointing out wherein useful lessons may really be learned from America. In electric railway construction we are behind, although efforts are now being made by some of our railway companies to introduce electric traction on branch lines. In this matter American experience is instructive, and the results already obtained in that country should be an inducement to our railway directors to lose no time in pushing forward their schemes; for not only have electric lines in America brought an increase of prosperity and activity to the districts through which they run, but they have also brought more business to the steam lines. We have not yet arrived at the complete solution of the problem of electrification of long main lines, but for branch lines serving as feeders electric traction is peculiarly suitable. Another matter in which lessons may be learned from America is the planning and equipment of main terminal stations, so as to make the personal comfort of passengers as great as possible, and to provide every facility for rapid booking. In this respect, as well as in others, the description of the Boston South Station is of particular interest.

It is clear from Col. Yorke's Diary that his time in America was very fully occupied, and that his trip was by no means a holiday. He has worked hard, and consequently has been able to bring home much valuable information, which amply justifies the action of the Board of Trade in sending him out. The American railway authorities have done everything in their power to enable Col. Yorke to obtain what he wanted, and their kindness and courtesy will be appreciated not only by the actual recipient, but by every person in this country who is interested in railway progress.

The Widening of London Bridge.

ALTHOUGH the construction of the Tower Bridge has afforded very considerable relief to vehicular traffic across the Thames, foot passengers still suffer from lack of accommodation. This is very natural, for the crowds daily turned out from London Bridge station consist largely of those who have business to perform in the City, and in addition to railway passengers using the bridge there are thousands of persons of both sexes who walk from home to business, or avail themselves of tramway or omnibus accommodation for the first part of the journey.

With the object of facilitating traffic, the Bridge House Estate Committee decided to increase the width of the footways as they have existed on London Bridge for the last seventy-two years. The scheme first proposed was to employ cast-iron cantilevers for the purpose of carrying the extensions, and the plans included the singularly inappropriate detail of a cast-iron balustrade. Fortunately, wiser counsels have prevailed, and the system now in course of adoption involves the fixing of a line of detached granite corbels, 650 in number, along each side of the structure. These corbels will support the projecting footpaths, which add 4 ft. 6 ins. to the existing width of 9 ft. 6 ins. each. It is never satisfactory to tamper with an engineering or architectural work, such as that which forms the subject of the present article, but if such work becomes necessary, it must be carried out with the least possible interference with the character and stability of the structure. As our readers will be able to judge from the illustrations reproduced, these conditions will be fairly complied with. No addition to or alteration of the foundations is contemplated, and the added corbelling is in character with the original design. Moreover, the projection of the new work will be within the line of the existing projection at the piers. Fig. 1 contains a section between corbels on the spandril walls, and the side elevation of a corbel over the bridge spans, by which the nature of the alterations will be made clear. The existing work is to be cut down to the level to the tops of the arches, so some of the corbels will rest directly upon the arch stones, and the remainder upon the top stones of the spandril walls. The spaces between the corbels will be filled by stones shaped so as to form, with the lower portion of the corbels, a continuous cornice along the face of each span. As the stability of the projecting footway depends entirely upon the corbels, considerable care was bestowed upon their design, and the method of fixing for adoption. It was originally intended that the root of the corbel should be dressed so that the sides of the stones would be approximately parallel. On examination of the drawing of the corbel, it became evident that the overhanging portion, without any applied load, would be practically of the same weight as the part imbedded behind the face line of the arch. Hence it was decided that the hinder portion of each corbel should be left rough, the front portion only being worked to the dimensions shown in the drawing. This alteration gives the advantages that the stones will be in equilibrium when placed in position, and that a better tooth exists for the concrete filling. Of course, it is not intended that the corbels shall hold up the weight of the widened footway without some additional anchorage, and it will be seen by the section that the necessary fixing is afforded by two 1-in. lewis bolts to each corbel imbedded about 2 ft. in the existing work, passing up each side of the stone and through a continuous 6 in. × ½ in. and 4 in. × ⅜ in. channel. Where the corbels rest directly upon the arch stones, the lewis bolts extend 9 ins. only below the bed of the new work. With the object of affording some relief to the corbels a joist,

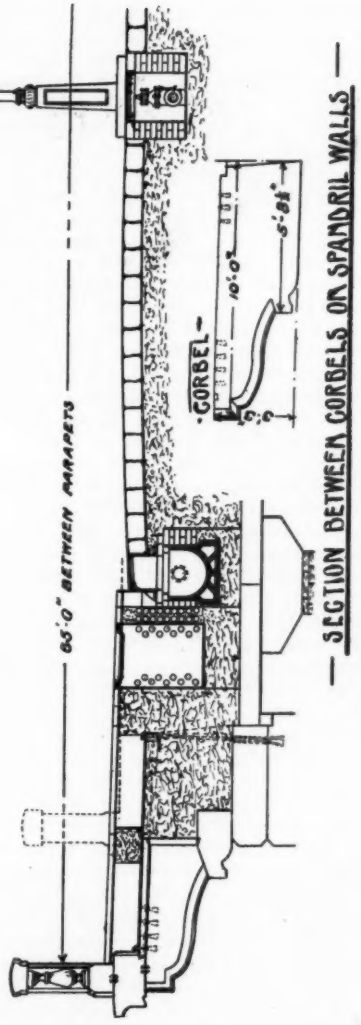


FIG. 1.—SECTION AT ARCHES AND ELEVATION OF CORBEL.

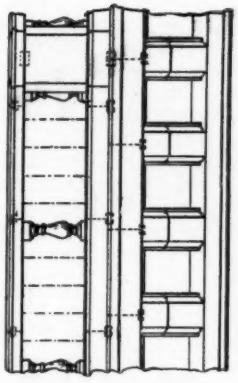


FIG. 2.—ELEVATION OF CORBELLING.

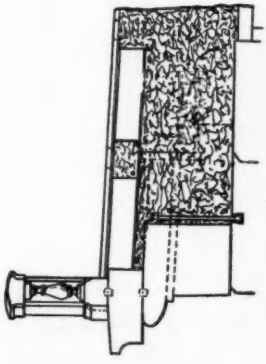


FIG. 3.—SECTION A PIERS

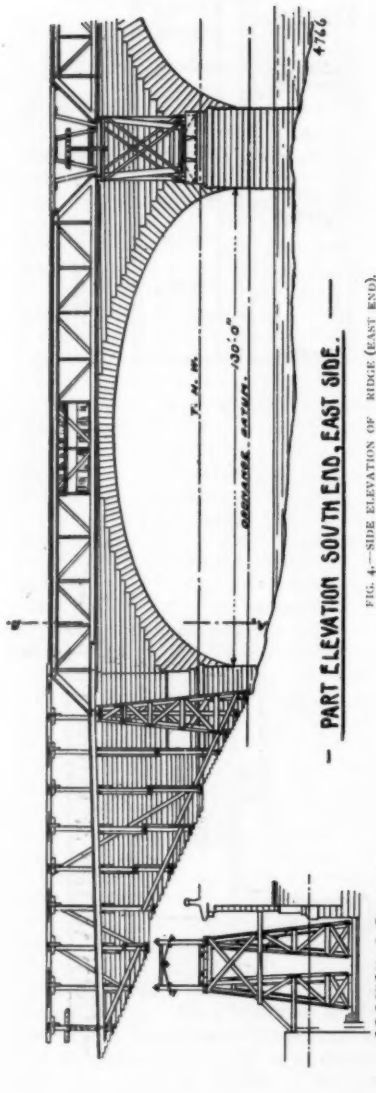


FIG. 4.—SIDE ELEVATION OF RIDGE (EAST END).

FIG. 5.—SECTION SHOWING FRONT OF TIMBER TRESTLES.

formed of one T-bar, 6ins. by 3ins. by $\frac{1}{2}$in. and one angle-bar, $2\frac{1}{2}$ ins. by 3 ins. by $\frac{1}{2}$ in., is secured at one end to the continuous channel, and passes over the axis of each corbel, to which it is fixed by seven $\frac{7}{8}$-in. lewis bolts The base stones of the balustrade rest upon the ends of the corbels, being kept in position by slate dowels and by cramps bolted to the joists mentioned. A similar course is followed at the north and south abutments, where, however, only six bolts are used, and no cramps are necessary for holding the base stones of the balustrade. Fig. 2 is an elevation showing the corbelling and a portion of the open balustrade, replacing the present solid work, this modification being necessary for the sake of appearance, as well as for reducing the weight to be carried. The alterations required at the piers may be gathered from an inspection of Fig. 3. The existing work is to be cut down to the line shown, and the balustrade will then be erected on the new stones shown in the section, these stones being secured in position by lewis bolts and cramps.

As the security of the new footways depends upon the strength of the corbels, the greatest care has been taken with regard to the quality of the stone. The contractors, Messrs. Pethick Bros., of Plymouth, are fortunate in possessing excellent granite quarries in Devonshire, from which the whole of the corbels have been cut. All the stones are tested in pairs under a transverse load of 4 tons, applied under conditions precisely similar to those that will obtain when the corbels are fixed in position on the bridge. For the purpose of ascertaining the ultimate strength of the material three stones have been tested to destruction, the final load being equal to 100 tons. One incidental advantage following the alterations in hand will be the provision of adequate accommodation for pipes and other conduits, as shown in Fig. 1. The whole of the roadway is to be renewed, one-half at a time, so that traffic shall never be entirely interrupted, and before being repaved a new layer of concrete, 6 ins. deep, will be laid over the existing clay filling. It should be mentioned that in addition to the widening of London Bridge itself, the

small arch spanning Thames Street is also being widened, so that an adequate approach may be afforded at the northern end of the bridge.

In order to provide for the execution of the works outlined above, without interfering with traffic to any considerable extent, it was decided that a temporary bridge should be erected at each side of the main structure, to afford accommodation for foot passengers, and to serve as a staging from which the masonry work could be conducted in part. The construction and erection of the two footbridges has involved a large amount of work, and the exercise of much ingenuity. Each bridge consists of ten steel braced girders, two of 157 ft. 9 ins. span, and the others of 146 ft. 3 ins. span. The spans weigh from 50 to 60 tons each, and they are supported upon cantilever steel trestles resting on the cutwaters of the piers. The shore ends of each footbridge are carried by timber trestles erected on the stone steps leading down to the river, and the timber approaches are supported by the same trestles, and by a number of timber frames also erected on the steps. Fig. 4 is a part elevation at the east side of the Southwark end of the bridge, and shows the general character of the approaches, the bridge spans, and the supports. Fig. 5 is a section of the footbridge near Fenning's Wharf, showing a front elevation of the timber trestle. The cantilever trestles resting at the bottom on the cutwaters, abut against timber blocks placed in front of the piers at the top, and are held up by 12 ins. by 1 in. steel tie-bars, two to each pair of trestles on opposite sides of the permanent bridge. Lateral movement of the trestles is prevented by hard wood wedges, driven between each pier side and the outer webs of the horizontal members of each trestle. Fig. 6 will serve to indicate the general nature of the arrangement adopted, and Fig. 7 shows the trestles in position on the bridge. The first work to be undertaken was the erection of the various trestles, and the extension of the cutwaters, by the addition of timber "dolphins" for the protection of the steel trestles. The steel spans were then erected on a pontoon, and hoisted into position

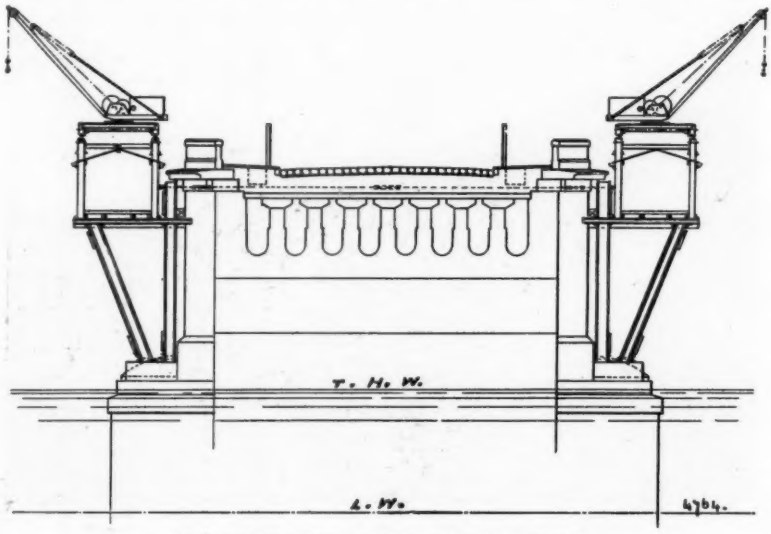


FIG. 6.—SECTION SHOWING SUPPORTS OF TEMPORARY BRIDGE.

one at a time, and the remaining details of the bridges were afterwards completed.

The horizontal members of the cantilever trusses supporting the spans consist of box girders, built of channels 12 ins. by $3\frac{1}{2}$ ins. by $\frac{3}{4}$ in. by $\frac{1}{2}$ in., and flange plates 20 ins. wide by $\frac{1}{2}$ in. thick, connected by a transverse girder built of channels 10 ins. by $3\frac{1}{2}$ ins. by $\frac{1}{2}$ in., and flange plates 7 ins. wide by $\frac{1}{2}$ in. thick. Beneath these three members cross-bracing is provided by 6 ins. by 6 ins. by $\frac{1}{2}$ in. angle-bars. The vertical and diagonal uprights of the trestles are of box form, the former built of $3\frac{1}{2}$ ins. by $3\frac{1}{2}$ ins. by $\frac{3}{8}$ in. angles, $\frac{3}{8}$ in. plates, and $\frac{5}{16}$ in. by $2\frac{1}{2}$ ins. bracing bars, and the latter of 3 ins by 3 ins. by $\frac{3}{8}$ in. angles and $\frac{3}{8}$ in. web-plates. The verticals measure 2 ft. by 1 ft. 1 in. over all, and the diagonals 1 ft. 6 ins. square. Both sets of uprights are supported by strongly-built box girders on the bridge cutwaters, these girder foundations, as well as the trestle uprights, being tied transversely by steel braces. In some instances, owing to previous subsidence, it was found necessary to adjust the level of the existing cutwaters by adding a bed of Portland cement concrete. Two sets of diagonal ties are fitted to each trestle, one set connecting the opposite corners of the vertical posts, and the other the corresponding corners of the diagonal posts, as shown in Fig. 8. Other details in the same illustration will be the subject of mention later. The tie-bars connecting the east and west trestles are in two lengths each, joined in the middle, as shown in Fig. 6. Although there are two tie-bars at each trestle, the safety of every span depends upon only one tie, and it would have been wiser if the bars had been in duplicate. We have no doubt whatever that the engineer responsible has allowed an ample factor of safety, but it is manifestly impossible to predict what flaws or faults may exist in a long piece of one-inch rolled plate. An additional measure of safety would therefore have been afforded by the use of two tie-bars at each point, each bar capable of taking the entire load, with a good factor of safety, in case of failure

FIG. 7.—PHOTO. SHOWING CANTILEVER TRESTLES.

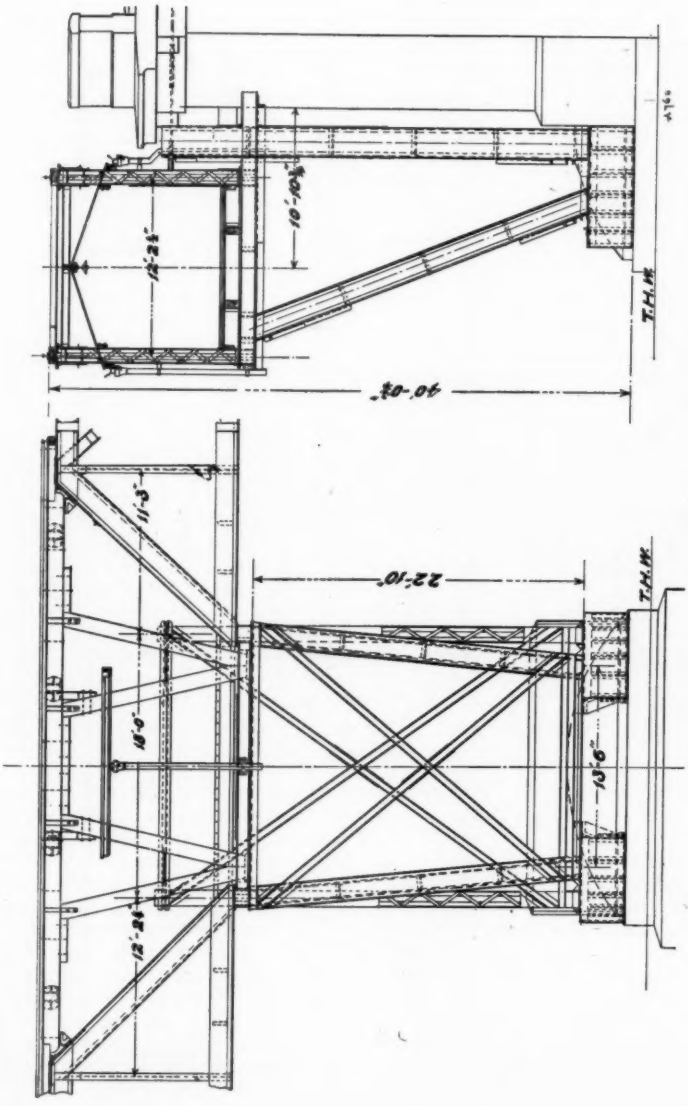


FIG. 8.—SIDE ELEVATION AND SECTION OF CANTILEVER TRESTLES.

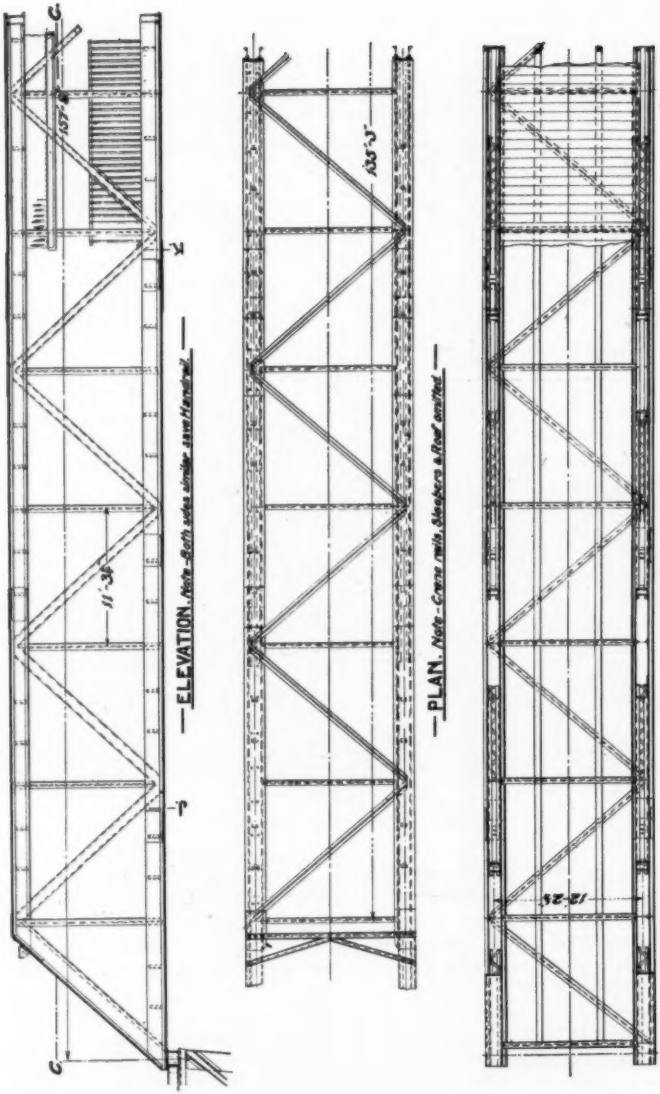


FIG. 9.—ELEVATION AND PLANS OF GIRDER SPANS.

of the other bar. In order to prevent obstruction to traffic, the ties were placed in position during the night, the laying of each bar occupying two nights.

The ten girder spans of the temporary bridge are of uniform height and width, of 12 ft. 6 ins. and 13 ft. 2½ ins. respectively, the only difference being in length. Fig. 9 includes a side elevation, and two plans of half the centre span. The lower boom is of trough pattern, being built of 3½-ins. by 3½ ins. by ⅜-in. angles, 20 ins. by ⅜-in. flange plates, ½-in. flange cover plates, ½-in. web plates, and ⅜-in. web cover plates. Diaphragm consisting of 2½ ins. by 2½ ins. by $\frac{5}{16}$-in. angles, and $\frac{5}{16}$-in. plates are fixed at intervals. The upper boom is composed of 20 ins. by 3½ ins. by 3½ ins. by ⅜-in. angles, ⅜-in. and ½-in. flange plates, ½-in. flange cover plates, ½-in. web plates, and ⅜-in. web cover plates. Sections of the upper and lower booms are given in Fig. 10. The struts and ties of the bracing consist of channel bars of various sections, from 10 ins. by 4 ins. by $\frac{7}{16}$ in. down to 6 ins. by 2½ ins. by ⅜ in. The diagonal struts are 1 ft. deep, and the channels are connected at each side by bracing bars, consisting of 2½ ins. by $\frac{5}{16}$-in. angles, as shown in the detail drawing in Fig. 9. The diagonal ties are 1 ft. deep, and of box section, the sides being formed of plates, 5 ins. wide by $\frac{5}{16}$ in. thick, while the vertical web members each consists of two 6 ins. by 3 ins. by ⅜-in. T-bars with 2½ ins. by $\frac{5}{16}$-in. diagonal bracing bars. An angle-bar rail is riveted along the lower edge of the web plate on each side of the upper boom of the girder, imparting stiffness to the structure. The inclined post at each end of the girder consists of 3½ ins. by 3½ ins. by ⅜-in. angles, 16 ins. by ⅜-in. flange plates, and 18 ins. by ⅜-in. web plates. At the upper ends of each pair of inclined posts, a portal bracing is provided by means of two 6 ins. by 3 ins. by $\frac{13}{16}$ in. T-bars. By the plan contained in Fig. 8, it will be seen that the horizontal panels are of the same spacing, and are otherwise somewhat similar to the vertical panels of the girder. Between the upper booms the transverse wind ties are 6 ins. by 4½ ins. by (20-lb.) T-bars, and the diagonals consist of 6 ins. by 5 ins. by ⅜-in. T-bars, but between the lower booms the transverse ties are 12 ins. by 5 ins. by ½-in. (32-lb.) steel joists. These members serve the purpose of floor-beams, to which two pitch-pine floor-joists, each 12 ins. by 5 ins., are secured by 3 ins. by 4 ins. by ⅜-in. angle brackets. Bearers for carrying the flooring are also bolted to the inside web plates of the two lower booms. These details may be observed in Fig. 8.

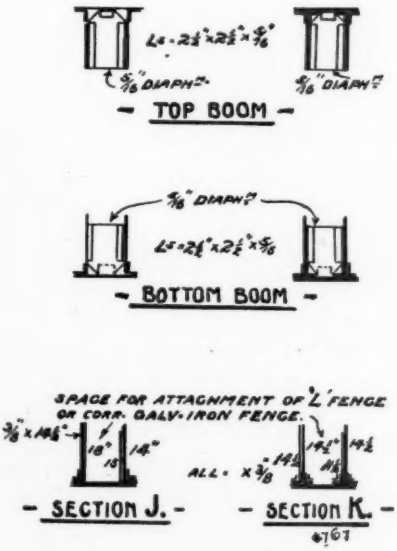


FIG. 10.—SECTIONS OF TOP AND BOTTOM BOOMS.

Having now obtained an idea of the leading features of the footbridge supports and girder spans, it will be convenient to deal with the method of erection before describing the remaining details of the two structures. Each of the twenty girders forming the ten spans of the two bridges was riveted up in separate sections in the yard of the sub-contractors, The Patent Shaft & Axletree Company, of Wednesbury. The spans were delivered by barge in small sections capable of being handled by a five-ton crane, which was placed on

the pontoon, and these sections were bolted together for convenience in erecting and taking down the temporary bridges. We believe it was originally stipulated by the engineer that the spans should be erected and brought to the site at some height above their ultimate level, and placed on their bearings by the falling of the tide. Realising the difficulty of moving great weights at such a height above water, the contractor's agent, Mr. Muirhead, suggested, when Messrs. Pethick Bros. were making up their tender, that the time uncertain. The scheme involved the use of four uprights on the pontoon, with two cross-heads, which were made movable to permit of the pontoon being free for removal. It was found that the system worked admirably; and it should be added that the sub-contractors introduced a further improvement by making two of the pontoon uprights movable. The whole ten spans were built on the pontoon and placed in position without hitch or mishap of any kind. The pontoon employed on this occasion was about 120 ft.

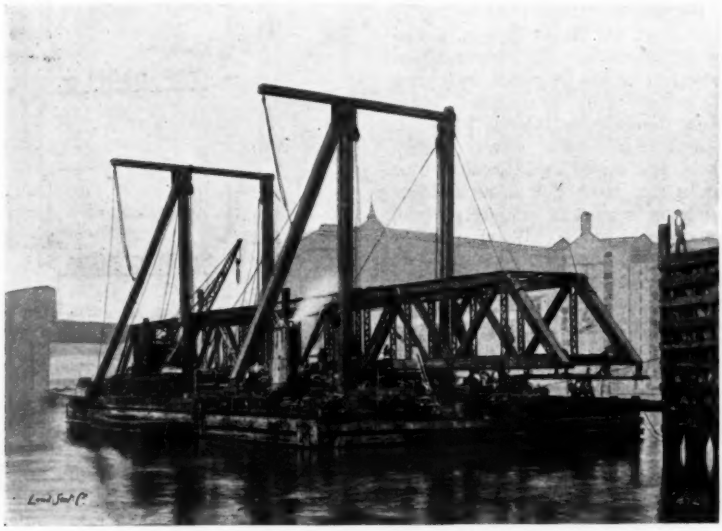


FIG. 11.—PHOTO. SHOWING PONTOON READY FOR LIFTING.

girders should be built on the deck of a pontoon—which, fortunately, the contractors had available—and lifted to the required height just when the pontoon was towed near the position in which each girder was actually to be fixed. The adoption of this method enabled the actual lowering of the girders upon their bearings to be done by means of the tackle used for raising, and so the operations could go on independently of the falling of the tide, which is at any

long by 60 ft. wide, consequently some 20 ft. of the largest girder projected at each end, and there was ample space on the deck for the portable steam-crane used in erection and four steam-winches employed for hoisting, and for spare materials and tackle required by the erectors. The main uprights in each case consisted of two pitch-pine posts, 50 ft. high by 20 ins. square, connected at the top by a crossbeam, from the projecting end of which guys were slung and

attached to the inclined strut, as shown in Fig. 11, which represents the centre span ready for being lifted into position. Fig. 12 shows the span lifted to its full height. As constructed, the crossbeam could be uncoupled from the upright on the far side, that is, the side next to the bridge, after the hoisting process; it could then be swung clear, and as the upright was also hinged the withdrawal of the pontoon would be perfectly easy. The spans were fitted together on steel cradles on the deck of the pontoon, and the operation of erection and bolting up complete occupied about 48 hours, while the average time, including towing to site and erecting in position on the cantilever trestles, was about four days per span. Thus, including all stoppages, the bolting up and erection of the spans in place occupied about 50 days, which is a remarkably satisfactory performance. Fig. 13 is a view of London Bridge showing the centre span of the footbridge in position, and another span on the pontoon ready for hoisting.

FIG. 12.—PHOTO. SHOWING PONTOON LIFTED.

As it was necessary to use the top of the footbridges for carrying metals for the travelling cranes to be employed in connection with the masonry work on the main bridge, suitable means were adopted for joining up the separate spans at the upper booms. The form of construction adopted is shown in Fig. 8, where it will be seen that the framework consists of inclined struts of 12-in. square timber, resting upon the steel beams connecting the uprights of the cantilever trestles, and supporting 13-in. square longitudinal timbers, secured by $3\frac{1}{2}$ ins. by $\frac{1}{2}$ in. straps with 1-in. bolts. The ends of the longitudinal beams are carried on brackets formed of $3\frac{1}{2}$ ins. by $3\frac{1}{2}$ ins. by $\frac{1}{2}$ in. angles and $\frac{1}{2}$-in. gusset-plates, these brackets being riveted to the inclined posts of the main girders, as illustrated in Fig. 9. Horizontal timber struts, 12 ins. by 6 ins., are fixed between the longitudinal timbers, being bolted to angle brackets. A space of 2 ins. is allowed for expansion between the ends of the longitudinals and the ends of the steel girders, this space being bridged by a short piece of timber, notched into the longitudinal beam at one end and bolted to the girder at the other. The rails for the travelling cranes weigh 50 lbs.

per yard, and are laid to 12-ft. gauge, on 13 ins. by 16 ins. longitudinal sleepers, held in line by 6 ins. by 5 ins. by $\frac{3}{8}$in. T-bar ties. It will be observed by the drawings reproduced that the whole of the temporary bridge is roofed in below the crane road. The roof is of corrugated iron, resting upon continuous timber stringers to the outside of which gutters are attached. The flooring laid upon the beams and joists previously mentioned, is of 9-in. by 3-in. planks, and the footways are fenced to a height of 4 ft. 3 ins., the fence on the river side consisting of an

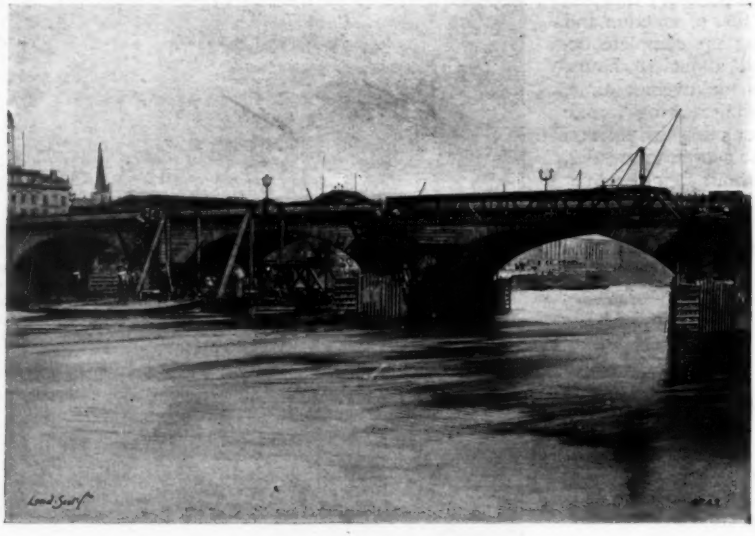


FIG. 13.—PHOTO. SHOWING ONE SPAN IN PLACE AND ANOTHER READY FOR HOISTING.

angle handrail, $2\frac{1}{2}$ ins. by $2\frac{1}{2}$ ins. by $\frac{1}{4}$ in., with vertical angle bars, $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. by $\frac{1}{8}$ in., spaced 6 ins. apart. On the side facing the bridge, the fencing consists of corrugated iron with suitable supports.

Four electric travelling cranes, each capable of lifting four tons, are provided for use on the crane road; and these will be extremely useful in dealing with the heavy stones removed from the bridge and with the new stones about to be put in. Before being opened to the public, both the temporary bridges were subjected to a test load, consisting of two travelling cranes and a train of trucks loaded with large stones. Levels were taken at three points in each span, and it is satisfactory to know that the deflection observed was not more than about $\frac{1}{8}$ in. at the centre.

The widening operations are being conducted from the designs and under the superintendence of Mr. E. Cruttwell, M.Inst.C.E., and of Mr. A. Murray, F.R.I.B.A. Mr. W. Muirhead, A.M.I.C.E., is the agent and engineer representing the contractors, Messrs. Pethick Bros., of Plymouth.

Recent Locomotives.

THE illustration on p. 436 is that of a four-cylinder engine, designed by Mr. H. A. Ivatt, to cope with the heaviest passenger traffic on the Great Northern Railway.

The engine, which was built at Doncaster, is not of the compound type. There are two cylinders outside and two inside. They are 15 ins. diameter by 20-in. stroke. There is only one motion and one piston valve for each side: that is to say, there are only four eccentrics, two links, and two valve spindles. The right-hand valve-gear distributes for the two right-hand cylinders, and the left-hand gear for the other side. The four coupled wheels are 6 ft. 7½ ins. in diameter; the bogie and trailing wheels 3 ft. 7½ ins. The tender wheels are 4 ft. 1½ in.; the total length of the engine over all is 35 ft. 2½ ins., and of the tender 23 ft. 1¼ in. The total wheel base of the engine is 26 ft. 9 ins. There are 17 tons on the driving, 15¾ tons on the coupled wheels, 15 tons on the bogie, and 10½ tons on the trailing wheels.

The leading dimensions are given in the following table:—

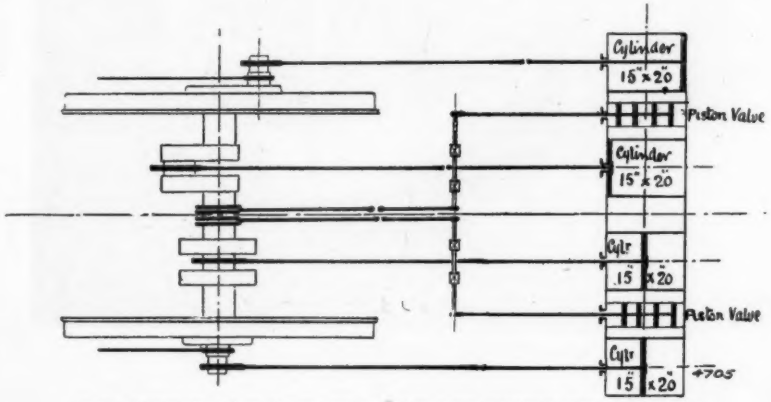
Boiler: 4 ft. 8 ins. diam. by 14 ft. long between tube plates.
Fire-Box ... ... 8 ft.
Number of tubes ... ...141; diameter, 2¼ ins.
Working pressure ... ... 175 lbs. per sq. in.
Heating surface:—
Tubes ... 1162¾ sq. ft. } Total, 1303 sq. ft.
Fire-Box 140¼ ,, }
Grate area ... ... 24½ ,,
Total weight of engine in working order 60 tons.
,, ,, tender ,, ,, 38½ ,,
Engine and tender ... ... 98½ ,,
Total weight of engine (light) ... ... 55½ ,,
,, tender ,, ... 18½ ,,
Capacity of tender, 3,140 gals. of water: 6 tons coal.

The diagram below shows the arrangement of the cylinders and motion.

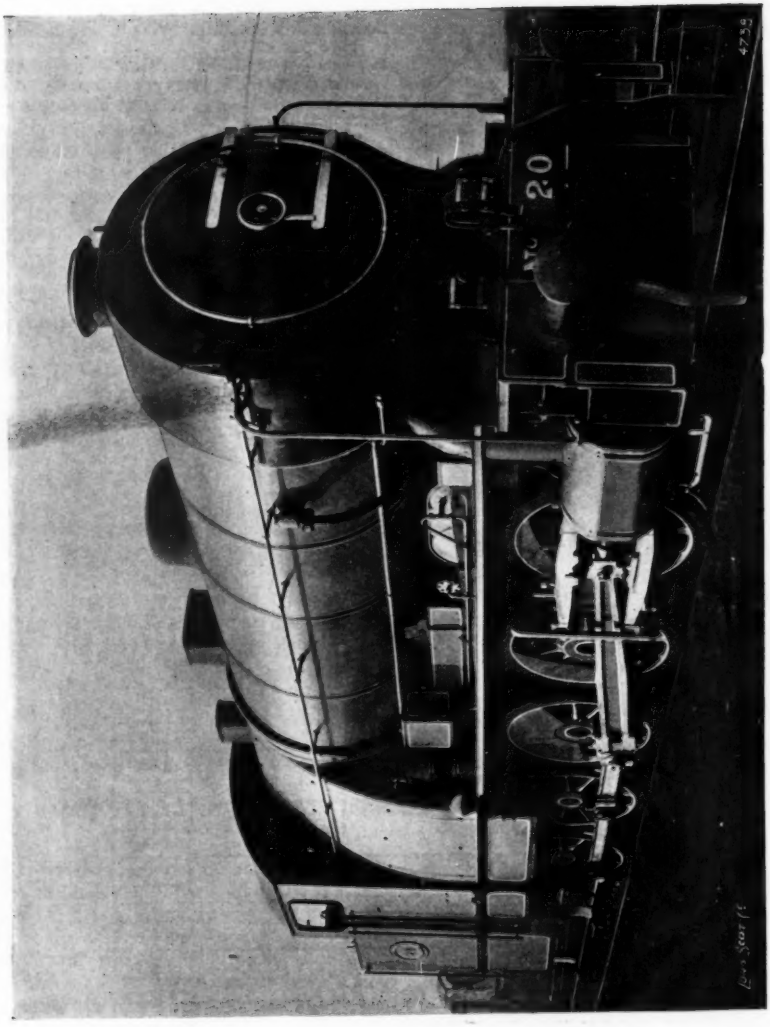
The engine has been at work for nearly seven months, and has, we understand, given complete satisfaction so far.

The second engine illustrated on p. 434 is a 10 wheels coupled tank-engine, and has been designed to give an accelerated service on the suburban system of the Great Eastern Railway, particularly between Liverpool Street and Enfield.

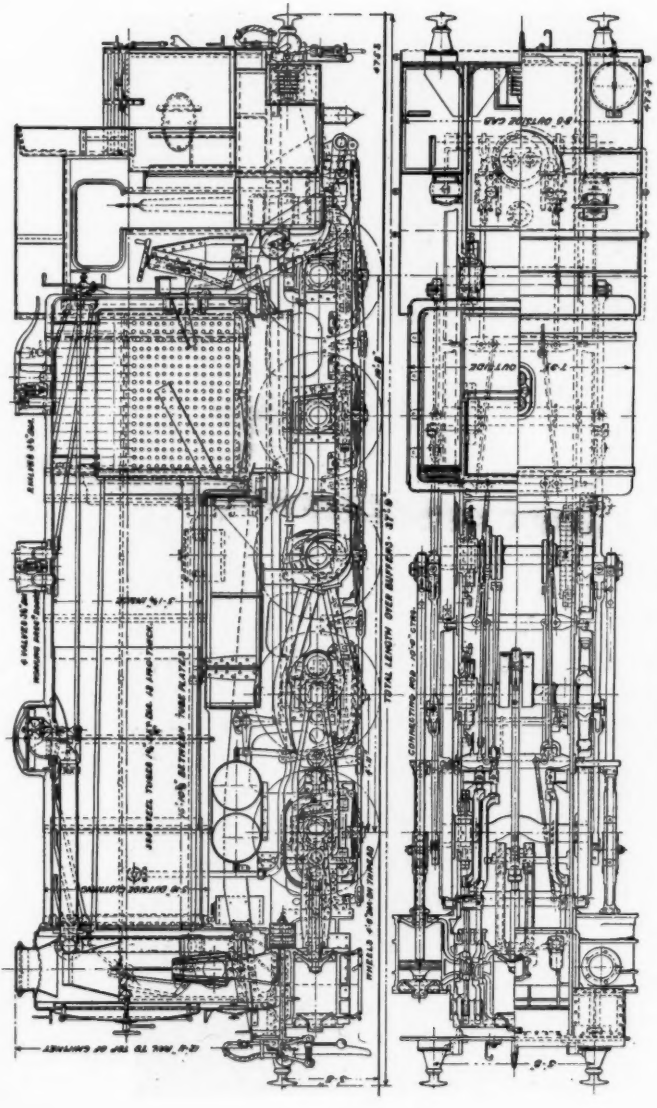
This portion of the line is 10½ miles long, with sixteen stations. It has hitherto been worked by engines which are capable of attaining a speed of 20 miles an hour at



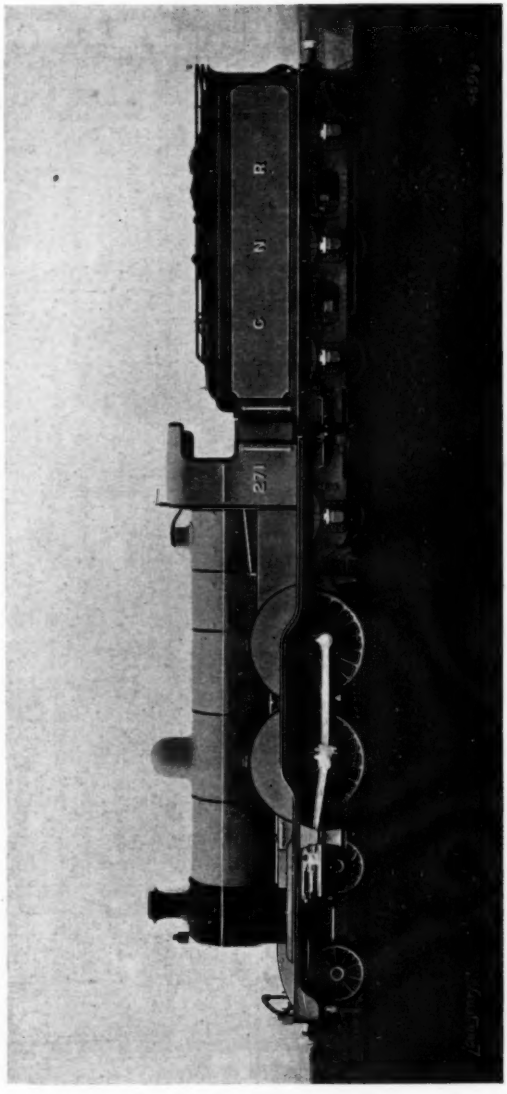
FOUR-CYLINDER PASSENGER LOCOMOTIVE, GREAT NORTHERN RAILWAY: DIAGRAM SHOWING ARRANGEMENT OF CYLINDERS, ETC.



TANK LOCOMOTIVE FOR SUBURBAN TRAFFIC: GREAT EASTERN RAILWAY.



TANK LOCOMOTIVE FOR SUBURBAN TRAFFIC: GREAT EASTERN RAILWAY.



FOUR-CYLINDER PASSENGER LOCOMOTIVE: GREAT NORTHERN RAILWAY.

30 seconds from the start with a train of 15 coaches, equal to a gross load of about 200 tons. Owing to the rapid growth of the population in this district in recent years, it has been necessary to take some extra steps to deal with the traffic. Some years ago the carriages were widened, with the result that each train had an increased carrying capacity of nearly 21 per cent. Difficulties, however, still arise, to meet which the "decapod" tank-engine has been designed.

The 10-wheels coupled engine will have a very high acceleration, which will enable it to pull a 50 per cent. increased load, and attain a speed of 30 miles an hour at 30 seconds from starting, saving about 10 minutes on the journey, and thus allowing of a more frequent service of trains.

The principal dimensions of the engine are as follows :—

Boiler :—		
Length of barrel	15 ft.	6¼ ins.
,, between tube plates	15 ,,	10⅝ ,,
Mean inside diameter ...	5 ,,	3 ,,
Working pressure, 200 lbs. per sq. in.		
395 steel tubes, external diam.		1¾ ,,
Firebox shell :—		
Width outside	7 ft.	9½ ins.
Length ,, ...	6 ,,	9½ ,,
Inside firebox :—		
Copper, plates ⅜-in. thick		
Length, inside	6 ,,	0 ,,
Width, ,, ...	7 ,,	0 ,,
Bronze stays, 1 in. diameter		
Heating surface :—		
External heating surface of tubes, ... 2878·3 sq. ft.	3010·0 sq. ft.	
External heating surface of firebox, ... 131·7 sq. ft.		
Grate Area	42·0 ,,	
Cylinders :—		
Three high-pressure, two outside frames, and one between frames on centre line of engine.		
Diameter		18½ ins.
Length of stroke		24 ,,
Centres of outside cylinders	6 ft.	8½ ,,
Wheels :—		
Ten, all coupled		
Diameter	4 ,,	6 ,,
Wheel base, equally divided ...	19 ,,	8 ,,
Length over buffers	37 ,,	8 ,,
Total weight, in working order	78¼ tons	
Adhesive weight	78¼ ,,	
Mean tractive effort (Mean effective pressure, taken at 80 per cent. of boiler pressure)	36,507 lbs.	
Adhesion at 500 lbs. per ton ...	39,125 ,,	

Manufacturing Section

❀ ❀ ❀

New Side-Planing Machine.

THE illustration on p. 439 is that of a new patent side-planing machine, having a special swivelling slide with tool-box, for planing the recesses and facings of engine-beds having angular bearings to receive caps. It has been designed to deal with all other kinds of angular work within its capacity, and by the use of this machine it is now no longer necessary to pack up the engine-beds or other work to the required angle, as these can be placed flat, either on the tables or floor, and the slide swivelled to the angle desired, and a saving in time thus effected. The capacity of the machine is 30 ins. wide by 7 ft. long, and in addition to its special function for angular work, it is adapted for a general class of planing.

The bed, which is mounted on legs, is carefully planed and scraped to a true surface on the top for receiving the saddle carrying the arm, and has T-slots planed out of the solid running the full length of the bed, to which the table plates carrying the tables are attached. The tables have vertical adjustment by screw and crank handle, and horizontal movement by rack, pinion, and ratchet handle. They are provided with T-slots on the top and both sides for holding work. The arm is driven by a steel screw of large diameter, and has a quick return of 80 ft. per minute. The slide can be swivelled to any angle up to 50 degs., and the tool-box has automatic cross and down feeds. The machine is fitted with a patent starting, stopping and reversing motion, actuated from the end of the arm, and roller bearings are provided for taking the thrust. The makers, Messrs. Geo. Richards & Co., Ltd., of Broadheath, inform us that they can supply this class of machine to deal with work of any length, and up to 48 ins. wide.

❀

Portable Air Compressing Plant.

ANOTHER interesting apparatus recently completed by the same firm is a portable air compressing plant, constructed for the Bengal-Nagpur Railway, India.

The plant, which is illustrated, consists of an air compressor, arranged to be driven by an electric motor by gearing direct, of an air receiver, water tank and all accessories, the whole being mounted upon a hand trolley suitable for a 4 ft. 8½ in. gauge.

The compressor, which is of the compound type, is capable of compressing 80 cub. ft. free air per minute to a pressure of 100 lbs. per sq. in. with the barometer at 29 degs. Fahr.

The cylinders are fitted with cast-iron liners of special mixture and bored truly parallel, the space between the liner and the shell forming the water jacket.

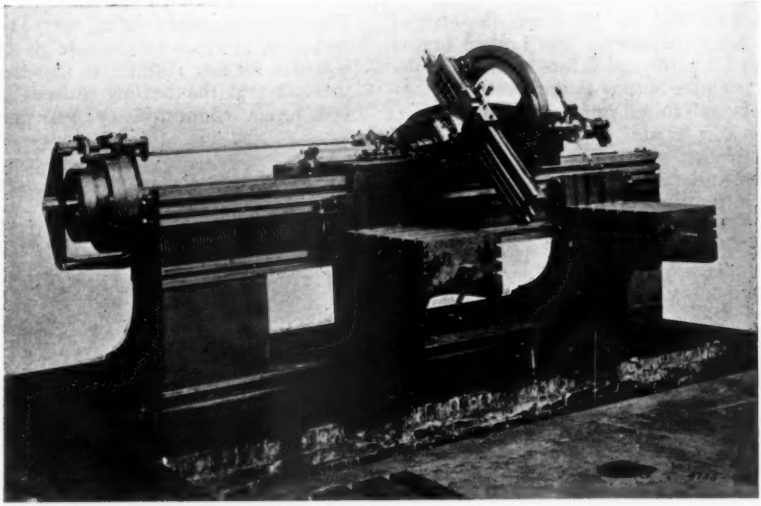
The cylinder covers are fitted with Mathewson's patent valves.

The main bearings are formed in the compressor bed and are fitted with adjustable two-part gun-metal steps.

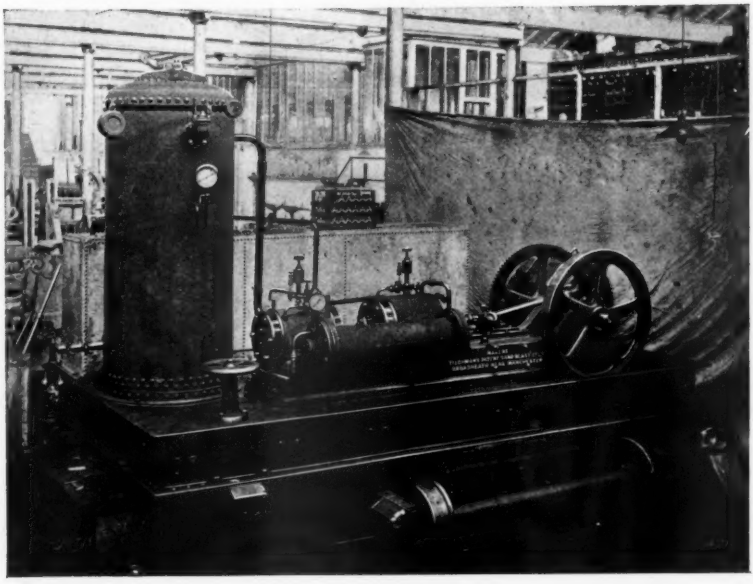
The driving gear consists of a cast-iron spur wheel fitted to the compressor shaft and a raw-hide pinion fitted on to the motor shaft.

The intercooler is of the pipe pattern, and is fitted with Row's patent copper tubes. It provides a cooling surface of 16 sq. ft.

The air receiver, which is of steel, is



NEW SIDE-PLANING MACHINE.



PORTABLE AIR-COMPRESSING PLANT.

5 ft. 6 ins. high by 2 ft. 6 ins. diameter, of 25 cub. ft. capacity. The bottom end is dished inwards and is fitted with an angle-iron ring for bolting to the truck.

The galvanized iron water tank is 10 ft. long by 3 ft. wide by 1 ft 9 ins. deep, and is provided with a loose lid 4 ft. long and fitted with rubber packing to prevent the water from splashing over when the trolley is moved.

The latter is built of mild steel of ample strength with forged eye-bolt at each end for coupling chain, and is also fitted with eye-bolts for lifting purposes. The axles are of mild steel 3½ ins. diameter, and are fitted with four steel flanged wheels having suitable axle-boxes with oil wells.

The motor for this equipment has a speed of 700 revolutions per minute, and includes a suitable starting switch.

The compressor is fitted with a low-pressure cylinder 8 ins. diameter, and a high-pressure cylinder 6 ins. diameter, the stroke of both being 10 ins.

A patent automatic inlet valve is fixed on the inlet side of the cylinder, so that when the working pressure is exceeded the inlet is automatically closed, putting the piston into equilibrium by causing a partial vacuum on both sides of the piston. This allows the compressor to run free (or without resistance).

The cooling water is circulated, and at the same time cooled, by means of a small air-lifting jet fixed on the high-pressure cylinder.

Hydraulic Plate Bender.

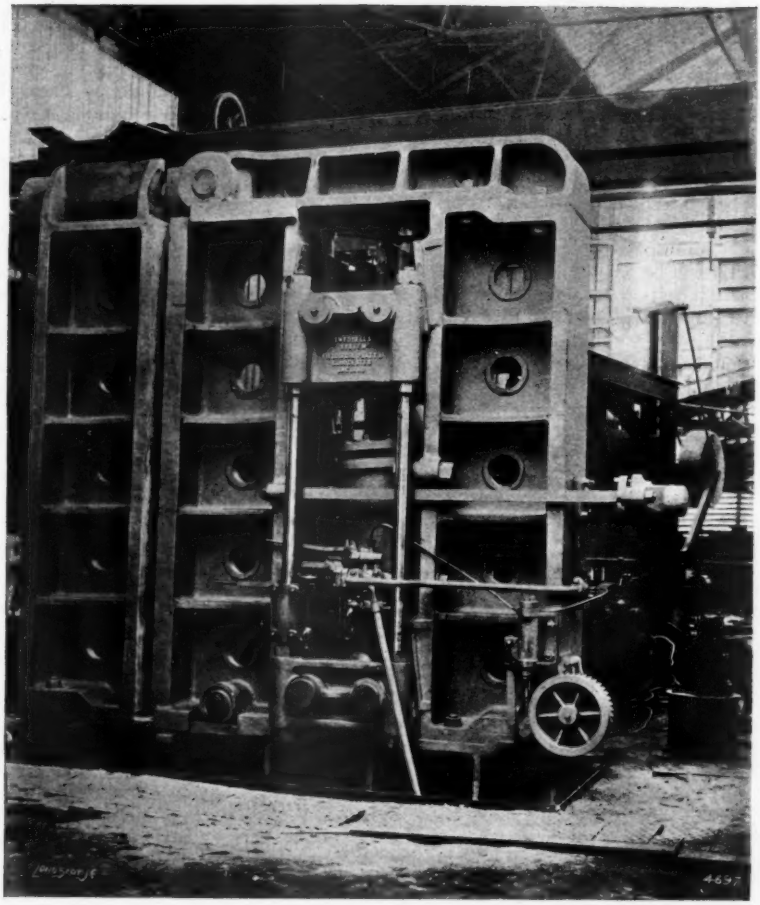
THE accompanying illustration represents an hydraulic plate-bending machine, recently built to the order of Harland & Wolff, of Belfast, and made according to Tweddell's system by Fielding & Platt, Limited, of Gloucester. It is designed to deal with 12-ft. plates 2 ins. thick.

As will be seen, the machine consists of three vertical girders resting upon a ribbed bed-plate, to which two outside girders are bolted. Further stiffness is imparted by the fact that the bearing surfaces are at two levels, connected by perpendicular faces, so that there is a right-angled joint in each case. The two end girders are also tied together at the top, and there is a hinged bolt, so that plates which have been bent to a complete circle can be lifted out. The centre girder is capable of horizontal motion on rollers and slides. The left-hand outside girder is made convex on the side pointing inwards, and the centre girder has its corresponding side concave. Motion is given to the centre girder by means of an hydraulic cylinder and ram working sets of wheels, which impinge on inclined surfaces. It is easy to understand that a large pressure may be put upon a plate placed between the left-hand and centre girders.

The makers claim that by it a plate may be bent to a true curve to the very end, and that narrow curved plates or joint strips can be bent as easily and accurately as complete steel plates.

The mode of working is as follows:—The plate is placed edge up on rollers on a cast-iron floor-plate, and is hauled through the machine in short steps of about 3 ins. each, by an automatic feed gear, at every stroke of the bending girder. The machine itself then takes in the straight plate, and turns it out bent to the desired curvature at one passage between the girders. As to quickness of working, we are informed that a plate 1⅝ in. thick and 13 ft. wide can be bent to its final curvature at the rate of from 2 ft. to 3 ft. per minute.

This type of machine is fast superseding bending rolls, and Fielding & Platt, Ltd., have made about 30 such machines, including three for the German Government yards at Keil, Wilhelmshaven and Danzig; besides such firms as Doxford & Sons, Hartlepool; Geo. Clark, Ltd., Sunderland; A. F. Craig & Co., Glasgow; Willans & Robinson, Rugby; Earle's Shipbuilding Co., Hull; D. Rowan & Co., Glasgow.



HYDRAULIC PLATE-BENDING MACHINE FOR MESSRS. HARLAND AND WOLFF.

A High-Speed Rotary Braiding Machine.

Our attention has recently been called to a piece of mechanism that gives promise of revolutionising a very important industry, and bringing back to England a trade that is largely diverted to Germany and France.

We refer to a high-speed rotary braiding machine, which it is claimed will average ten times the work of the present machines with a minimum of power and attention. This being true, of course the saving to manufacturers, not only in labour, but also in floor space, power, insurance, and so forth, will be something enormous.

There have been no great improvements in the machines used in this industry since the early 'eighties, though hundreds of attempts have been made by eminent engineers: yet the solution of the problem seems to have been a comparatively simple one, for by an easy rotary motion the threads are carried in a trochoidal path over and under each alternate bobbin without varying the tension at any point.

The feature that strikes the observer first is that the machine is built on entirely different principles to the braiders now in use, yet its simplicity and durability are apparent at a glance. It is absolutely rotary, not having one reciprocative motion, and doing away entirely with the slack threads or their equivalents. The thread is drawn directly from the spools or cops to the braiding point.

Referring to the illustration, the type of machine shown is a 16-carrier braider, having eight upper and eight lower bobbins or cops. The upper bobbins or cops hold seven ounces of material, and the lower bobbins are capable of carrying three pounds each. With increased speed increased bobbin capacity is essential. This braider can be run slowly, but is capable of enormous speed, and therefore of unusually large production.

In threading the machine, it is simplicity itself. The breakage of thread is provided for by an ingenious trip device which automatically stops the machine at 250 revolutions in half a revolution. The machine is adapted for what is known as circular or tubular braiding, and can be built to any of the forms to which this braiding is desired.

The high speed braiding machine has now passed the experimental stage, and is on the market at this moment. It is on exhibition, and can be seen at any time by parties making appointments with the builders, The High-Speed Braiding Machine Co., Ltd., 7, Norfolk Street, Manchester.

A practical man at a glance can see the strong points of this machine, besides witnessing the fulfilment of all the promises made. It represents eight years of strenuous labour on the part of the inventors and builders, also a vast outlay of money, and is fully covered by patents issued, allowed, and pending.

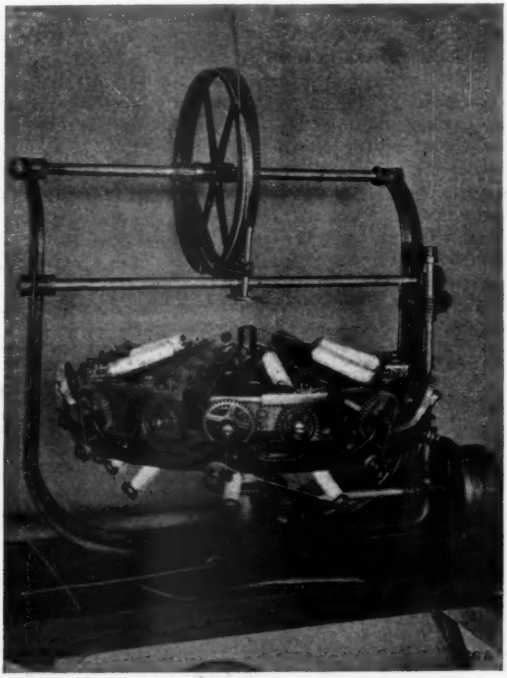
The price of this machine has been placed at a very low figure for a mechanical device which is not only well made but is sure to prove a money-saver to the manufacturer who places it in operation in his mill.

The saving in floor space by using this machine will prove an important consideration to manufacturers. It will save largely in the wages of machinists; the saving in space will amount to about two-thirds, and the saving in power will reach quite to this amount. Of course, involved in this is a saving in the matter of insurance, shafting, belting, oil, and general factory repairs.

This machine is particularly adapted to the manufacture of covering for insulating electric wires, of corset laces, shoe laces, wicking, clothes lines, window cords, curtain cords, braiding for furniture and other decorative purposes, fishing lines, rubber packing, trimmings, suspenders, watch guards, elastic cords, etc. The number of feet of braid and cord turned out per year in these lines of manufacture certainly amounts to a record quantity; and this machine has come to the front to permit manufacturers to obtain a much larger profit on these articles with a much smaller outlay of capital.

The labour unions will surely, it is to be hoped, welcome this innovation, which

interested parties say is a boon rather than a detriment to English labour, claiming that it will bring back a trade now almost controlled in certain branches by foreign competitors, for it is an acknowledged fact that large quantities of raw material are shipped from England to Barmen, Germany, and then returned as finished material to find a market here.



HIGH-SPEED ROTARY BRAIDING MACHINE.

Foster's Patent Steam Trap.

THE principle upon which this trap works is the expansion and contraction of a brass tube (T) under varying temperatures, the said expansion and contraction being multiplied to increase the sensitiveness of the trap, by the method in which the lever (L) is suspended. The lever (L) is hinged at one end on the pin (P) and connected at the point (X) to the inlet end of brass tube (T) by means of the adjusting rods (R), one on either side of the brass tube. The other end of the lever (L) carries a spindle (S_1) with hand-wheel attached, the end of which spindle impinges on the end of the controlling-valve spindle (S).

The end of the spindle (S_1) is screwed for a given distance, and screws into a loose plate (N), until it comes against a shoulder formed at the end of the screwed part. The loose plate (N) is free to slide along the studs (B), taking the spindle (S_1) with it, except for the resistance of the spring (H), which is sufficiently compressed by means of the studs (B) and

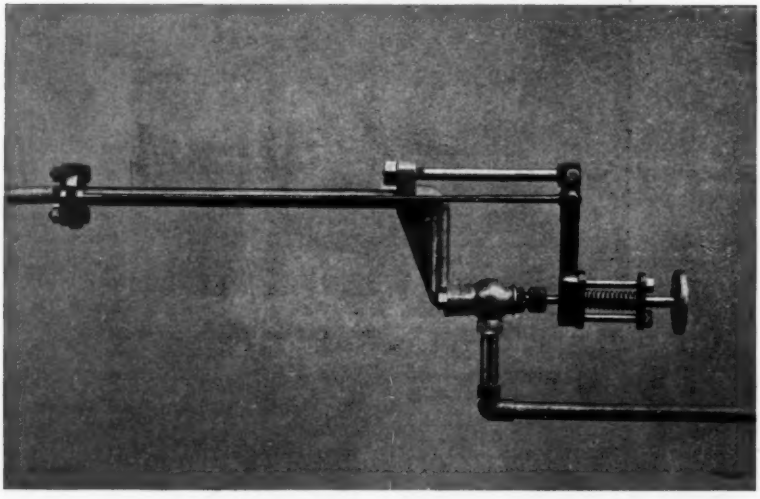
cross-plate (C) to prevent the loose plate (N) and spindle from lifting, until the force tending to lift it is such as would correspond to a pressure on the controlling valve (V) slightly over the working pressure for which the trap is constructed.

The object of the spring being that, should the controlling valve face or seat get damaged at any time, owing to grit or other foreign matter passing through it, and steam leak past it in consequence, when the trap would otherwise be closed, causing an abnormal expansion in the brass tube (T), which expansion, being multiplied as afore described, would cause an excessive pressure on end of spindle (S), the result of which would be excessive straining in all parts of the trap, but which is obviated by the spring (H) allowing the loose plate (N) and spindle (S_1) to lift under these conditions.

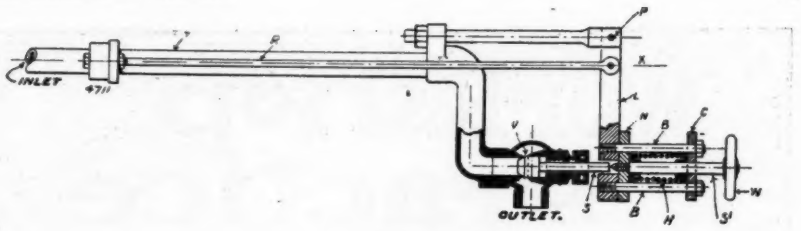
The spindle (S_1), by means of the hand-wheel attached, can be screwed back, thus allowing the controlling valve to open and steam to pass through to test the proper working of the trap. The controlling valve may thus be left open for a while, which is very convenient when steam is being turned into a long line of steam piping.

By simply screwing the spindle (S_1) in again until the shoulder formed at the end of screwed part touches the loose plate (N), the trap is restored to its proper working condition.

While it is not claimed for this trap that the controlling valve face or seat is more exempt from damage than in other designs of traps; yet it is a feature of the design that any such damage can be more easily put right than is the case in the majority of other designs; and, moreover, there are no pockets for the accumulation and retention of foreign matter, so that anything which may find its way into the trap can be blown clean out and prevented from causing trouble on another occasion. The apparatus is the invention of Mr. Frank Foster, 7, Glengall Road, Millwall Docks, E.



FOSTER'S PATENT STEAM TRAP.



FOSTER'S PATENT STEAM TRAP.

Superheaters for Newcastle Tramways Station.—The contract for the full equipment of superheaters for The Manors power station of the Newcastle-upon-Tyne Corporation Tramways undertaking has been awarded to Messrs. The Cruse Controllable Superheater Company, of Manchester. A trial set of three superheaters, fitted some eighteen months ago, under the specification of Mr. Chas. Hopkinson, M.I.C.E., M.I.E.E., has completely justified this gentleman's confidence in the Cruse system of superheating; and this contract is the outcome, the keen competition of much lower-priced rivals notwithstanding.

Middlesbrough Electricity Station.—In the March issue there was published an article describing a 300-k.w. triple-expansion engine at the Middlesbrough Electricity Station, in which it was stated that besides the 300-k.w. triple-expansion Corliss engine made by Messrs. Davy Bros. of Sheffield there is one 100-k.w. compound engine made by the well-known firm of Browett, Lindley & Co., Ltd., of Patricroft. We would now take this opportunity of pointing out that although this information is quite correct so far as it goes, there was an extension of the Middlesbrough Electricity Station made in 1901, which consisted of one of Messrs. Browett, Lindley & Co.'s three-crank triple-expansion high-speed enclosed type engines; and in 1902 a further extension of plant was installed, consisting of a similar 300-k.w. engine of the same make. Both these latter extensions were carried out by Messrs. Witting Bros. of London, who built the generators, and to whom Messrs. Browett, Lindley & Co. were sub-contractors for the engines.

The Phœnix Dynamo Manufacturing Co., of Bradford, who recently purchased the works, business, patents, etc., of the late firm of Rosling & Fynn, Ltd., inform us that they have now removed from their Joseph Street works to their new works, and request that all enquiries, correspondence, etc., may be addressed to them at Thornbury Works, Bradford. We may add that they have already found it necessary to extend the premises at Thornbury, which are now being equipped with modern machinery, designed to further increase the Company's output and enable them to give quicker deliveries of their specialities, in which they have been so successful in the past few years.

An Important Reconstruction.—The arrangements for the transfer of the business of Messrs. Askham Bros. and Wilson, Ltd., of Sheffield, to Messrs. Edgar Allen & Co., Ltd., of the Imperial Steel Works, Sheffield, have now been completed, under which Messrs. J. & P. W. Askham have acquired a considerable financial interest in that company. It has been felt for some time that in view of the increasing demand for tramways, owing to the rapid rise of electric traction, that increased space, plant, and facilities for meeting this demand should be made. Messrs. Askhams grappled with the problem, and secured advantageous plots of land, with the intention of building as extensive works as other manufacturers in England. Circumstances, however, were somewhat against this, owing to the illness and total incapacity from business of Mr. Philip U. Askham, the managing director. Negotiations were entered into as above-mentioned, and it is believed that not only will the amalgamation be for the benefit of the two firms, but also for tramway engineers and corporations generally. Mr. Fred Bland, who for many years has been well known in tramway circles, is remaining with the new firm as director of the tramway department; and as the entire staff has been taken over there will be no break in the continuity of the business. During the thirty-seven years that Messrs. Askham have carried on the business they have seen very great changes in trade. Commencing as steel manufacturers in 1866, they gradually increased their business, adding first one article and then another in the shape of tools, then crucible cast-steel castings, and then tramway points and crossings. They were the first manufacturers of crucible cast-steel points and crossings, for which, however, there was not a great demand for horse tramways; but when steam was introduced the demand was increased considerably, and having taken up or invented a patent automatic spring point, rendered compulsory by the Board of Trade, rapid extensions were made in their business; but when electric traction became the order of the day even this extension was doubled. In addition to the tramway business what was practically a separate department is carried on for the manufacture of crushing, grinding, and separating machinery; also elevators and conveyors.

Workshop Practice

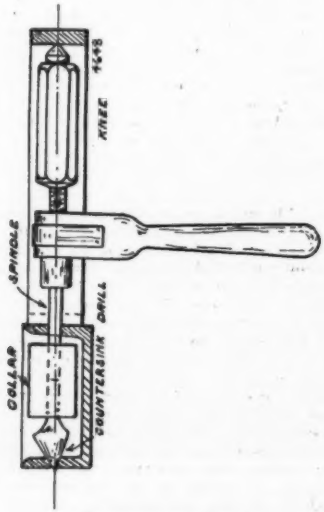
The attention of Works Managers, Foremen, and those under their charge, is particularly directed to this section, which has been designed for providing an opportunity of discussing all matters relating to the Machine Shop, Foundry, Pattern Room, and general practice, both Mechanical and Electrical. Contributions and answers to queries are paid for at scale rates. What we desire to encourage is inventive capacity and originality. Send along particulars, accompanied by rough sketches, of emergency devices, jobs which have taxed your ingenuity, etc.; they are worth recording.

❀ ❀ ❀

Countersinking Holes inside Channel Iron.

The sketch shows a simple device for countersinking holes on the inside of channel or H-iron girders. Short ratchets are generally used for limited space, but where possible the workman much prefers the boring knee with the ordinary ratchet. The device consists of a loose bush or sleeve with square hole and an auxiliary spindle, the ends of which are made to fit the sleeve and nose of an ordinary ratchet brace. The arrangement is shown in the figure—the sleeve with the countersink drill being placed in position inside the channel, and the spindle introduced from the other side, with the ratchet attached. This gives the workman the advantage of the boring knee, with more freedom of movement.

E. F.



COUNTERSINKING HOLES.

"Backing off" Formed Milling Cutters.

All artizans conversant with machine shop practice, know the undoubted value of the milling machine, and also the advantage of using formed milling cutters; but in a great many shops these cutters, after being turned to shape and having the spaces between the teeth milled out, are still "backed off" or relieved in a primitive fashion with chisel, file and scraper, the consequence being that the correct form is destroyed the first time of grinding. By the following arrangement, milling cutters can be "backed off" in the ordinary screw-cutting lathe, not as effectively as on a specially designed machine for the purpose, but with a little care sufficiently good for all practical requirements.

End mills or counterbores, such as are used for cycle hubs, cups, ball races, etc., can be backed off without any extra attachment, while the ordinarily formed milling cutter, which cuts on its periphery,

may be backed off with the aid of an easily made device cheap enough to accommodate the smallest shop.

To back off end milling cutters or counterbores, as illustrated at Fig. 1, the process is as follows:—Certain change-wheels are put upon the lathe spindle and leading screw respectively, to suit the divisions required; the cutter, having been previously turned to shape and the required divisions milled, is then put in the lathe, the shank held in a chuck or collet, and the front end just behind the teeth run in a steady rest. A tool of the required shape is then put in the rest of the top slide, and brought forward to just catch the back of one of the teeth; the nut is dropped into gear and the lathe pulled round, the tool moving forward sufficient to catch the back of the tooth. When the tool has moved into the space, the nut is taken out of gear and the saddle moved back to the starting-point, which will vary according to the number of divisions or teeth. This operation is continued, the cut being put on gradually by the top slide, until the tooth is brought up to a sharp edge, working from the back to the front, or cutting edge. The whole of the above action really amounts to cutting a section of a multiple threaded screw. If the lathe runs slow, and the operator is quick, the lathe could run continuously without being pulled round.

Example: to back off a cutter with five teeth, leading screw $\frac{1}{4}$-in. pitch. For a cutter with five teeth put a 50 wheel on the spindle, and a 20 wheel on the screw, with any intermediate, the ratio will be $\frac{2}{5}$, that is the screw will make one revolution, moving the saddle quarter of an inch forward, whilst the spindle makes $\frac{2}{5}$th of a revolution, the tool of course catching every other tooth, and there being an odd number of teeth in the cutter, each tooth is touched once every two revolutions of the spindle, the saddle in this instance being brought back $\frac{1}{4}$-in. each time. For backing off cutters with other numbers of teeth, with a $\frac{1}{4}$-in. pitch lead screw, it is advisable to keep the ratio somewhere about $\frac{4}{9}$ or $\frac{5}{9}$, so as not to make the cutting angle too keen, or not keen enough.

The wheel on the spindle must be a multiple of the number of teeth in the cutter, and the wheel on the screw must be such that it will divide the number of teeth into unequal parts.

Spindle.		Screw.	Ratio.	Will Divide.
70	into	30	$\frac{7}{3}$	7
90	,,	40	$\frac{9}{4}$	9
110	,,	50	$\frac{11}{5}$	11
*60	,,	25	$\frac{12}{5}$	12
65	,,	30	$\frac{13}{6}$	13
75	,,	35	$\frac{15}{7}$	15
†80	,,	35	$\frac{16}{7}$	16
85	,,	40	$\frac{17}{8}$	17
‡ 00	,,	45	$\frac{20}{9}$	20

* Will also relieve 6, but for a cutter with 6 teeth, the saddle must be brought back $\frac{1}{2}$ inch.

† Also 8, but for 8 saddle will have to come back $\frac{1}{2}$ inch.

‡ Also 10, but for 10 saddle must be brought back $\frac{1}{2}$ inch.

The same wheels that are used for 12 and 6 will also answer for a cutter with 4 teeth, but the saddle would have to be brought back $\frac{3}{4}$-in. each time. To back off cutters whose teeth are on the periphery, the process is just the same, but an

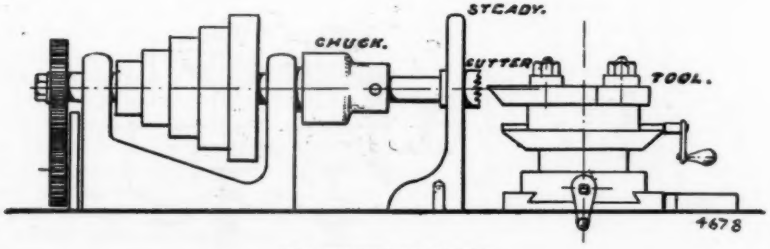


FIG. 1.—BACKING OFF CUTTERS.

attachment to the lathe must be used, so as to convert the motion of the lathe, from being parallel to the bed, to be at right angles to it.

This attachment, Fig. 2, should be fairly strong, but can be as plain as possible; it is a casting after the style of a lathe headstock, bored out to take a spindle, and having on its base a tenon (at right angles to the spindle) planed to fit into the bed of the lathe. On the spindle is a place for the formed cutter to be held, and there is also a mitre gear permanently keyed to it; this mitre gears into another screwed on the nose of the lathe spindle, as shown. The attachment can be made more elaborate if desired, but one as illustrated serves the purpose equally well. If the cutter is one with a complex shape, two or three tools would be used in the slide rest alternately, putting the cut on by the top slide. F. B.

Foundry Cupola.

I read with interest and pleasure the article published in the October number, especially as the writer's general remarks agreed with my own observations and experience. It is helpful, and gives confidence to those contemplating a departure from the beaten track of old practice, to have for their guidance the experience and knowledge of others who are working in the same direction; this interchange of ideas saving much expense and trouble in the experimental stage of progress. Having for some years made notes on this subject, and at the present time being engaged in designing a new plant, it may not be out of place to supplement the previous article by a few definite dimensions and methods that have been found profitable both in this country and America.

Situation.—The position of a cupola of small capacity may not be a matter of much moment, as the labour required for its working is not considerable; but as the "blows" increase in weight and frequency it is of the first importance, if smoothness and economy in working are desired, that the incomings and outgoings should be arranged in the most convenient manner possible. It is more difficult to carry away the molten metal than to wheel up pig, scrap and fuel, therefore the first consideration is a centre from which the metal may radiate from the cupola to all parts of the floor, either by means of trolleys, ladles or cranes. Where practicable, the charging platform should be on a level with the road supplying the materials for its use, and of such capacity that it may be made the store-house for pig, scrap and fuel, to enable the wagons to be unloaded direct, without delay. By this means much labour is saved in supplying the cupola. Where this cannot be done, a handy power jib-crane or hand-crane should be fixed to haul up the charge in buckets, to be dropped near the charging-hole.

Not the least important is the dimensions of the cupola. To enable this point to be decided, some approximate calculation should be made of the average weight of castings required each blow, and the probable heaviest blow that may be expected, also the amount of time that can be allowed for blowing.

Fig. 1 shows an ordinary parallel cupola, with air-belt, arranged for drop

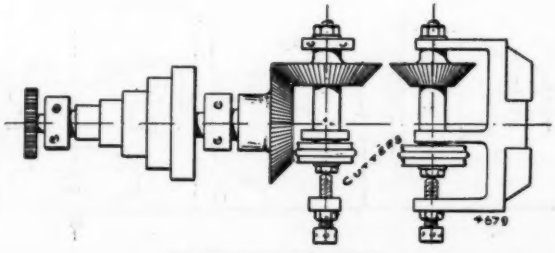


FIG. 2.—BACKING OFF CUTTERS.

bottom. The dotted lines at the bottom of the lining show how the diameter is reduced for the larger diameters, to enable the blast to reach all parts of the interior. The diagram is arranged for all cupola charges of diameter, from 24 ins. to 80ins., and the charges in the cupola shown have been taken from it.

Many patent cupolas will be listed to bring down the metal in good condition, with far lighter charges of fuel ; but much economy may be obtained in the common cupola by careful attention, and varying the charges until the minimum of fuel and maximum of metal for the cupola is ascertained, to bring down the metal hot and fluid, without starving.

Air Pressure.—For successful and expeditious melting, it is absolutely necessary that a good blast should be provided; disaster dogs the heels of the most perfected design if a weak or variable blast is provided, and there is no more certain way of producing a prolific supply of cuss-words around the melting area. By what means the air-pressure shall be obtained does not affect us. Blowers and fans can be obtained that do their work admirably; but some users have a weakness for those that drive without geared wheels. The dimension of the main air-pipe should err, if it errs at all, on the side of too much area; the fan driving-belts should also have the same direction. It is not desirable that the resin-pot should be required in the fan-house at every blow. It is not only necessary that a sharp, strong blast be provided, but that it should have sufficient amplitude to supply sufficient air for complete combustion. Wherever possible, a separate fan and main air-pipe should be used for the cupola; and if it is contemplated to take from it a branch pipe for the smithy, furnaces, or other purpose, take the advice of *Punch* and "don't."

The blast pressures shown have been found to give good results in practice, and should be constant. Some users claim to have obtained results by increasing the area of tuyere, opening gradually from the tuyere to the inside lining, giving the required amount of air for combustion and a softer and more equal distribution. If the pressure is not maintained, the supply of air is insufficient to support perfect combustion, and the gases escape; but it does not necessarily follow that it is good practice to force unlimited quantities of air into the cupola—there is a possibility of having too much of a good thing—and instead of supporting combustion and increasing the temperature, this would have a cooling and deadening effect.

Slagging.—During a heavy or protracted blow, or when using light and dirty scrap and pig, slag sometimes accumulates in objectionable quantities, and provision should then be made for running off the slag, by providing a slagging hole about 2 ins. below the tuyeres. In ordinary work, with good scrap and pig, this is unnecessary.

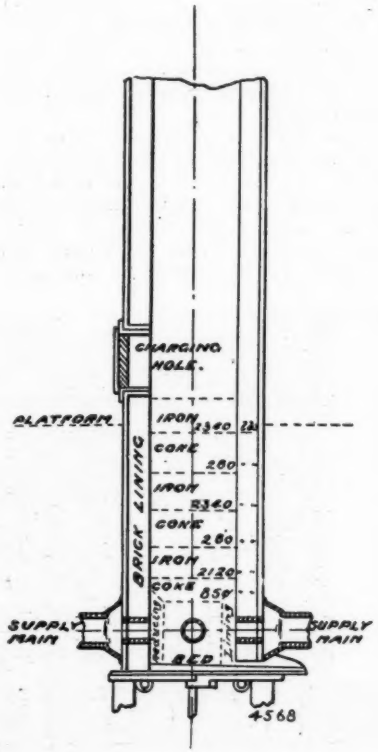


FIG. 1.—FOUNDRY CUPOLA.

Cupola Lining.—A careful furnaceman will daily be exercising himself in ascertaining the condition of his brick and ganister lining. The fire-brick lining should, when first laid, be well rubbed and bedded-in with fire-clay, mixed with sharp sand, and as it burns out of shape a thin coating should be rubbed on the cavities before each blow, until the original shape has been obtained. When the mending is put on too heavily, it is apt to fall out in blowing.

Many efforts have been made by inventors to get the air-blast distributed right through the core of the cupola. Where a wind-chest is used with a fair proportion of tuyeres, cupolas up to 50-in. diameter work well without any other provision, and can be made parallel. When this diameter is exceeded it is advisable, and in the largest sizes necessary, to reduce the diameter of the lining from about 12 ins. to 18 ins. above the tuyeres to the bed; the reduced diameter should not exceed 54 ins.

This article is dealing, not with the many excellent patent cupolas in the market, but with what may be expected from the average cupola, carefully designed, run by the average furnaceman under intelligent supervision; and the output and economy may beexceeded or diminished according to the efficiency or inefficiency of control. The height of the cupola should be decided with care, and should not be less than that given in the diagram (from the bed to the bottom of the charging-hole), to enable the combustible gases to combine with the oxygen, and give up its heat to the cupola instead of passing unburnt into the atmosphere.

Bed Charge.—This is calculated upon the dimensions given in the diagram, from the base to the bottom of the tuyeres; should it be desirable to increase this depth on account of dirty scrap, slag, or blast, the amount of the bed charge should be increased in proportion. The calculation is also based upon the assumption that the inside of the cupola is parallel up to a size of 54 ins. in diameter, which it is not common practice to exceed, owing to the difficulty of the blast reaching the centre. The height of tuyeres above the bed should not be exceeded without due consideration, however much the furnace tenter may desire it, on account of the increase in the bed charge that must necessarily follow. To provide for contingencies, it has been found advantageous to reduce the diameter by a few inches, from a few inches above the tuyeres to the bed; should it be required at any time to melt for an exceptionally

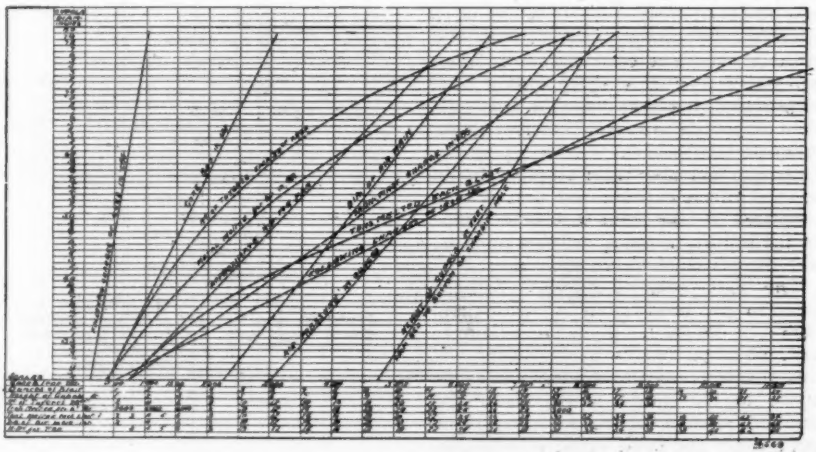


FIG. 2.—FOUNDRY CUPOLA.

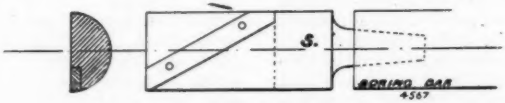
heavy casting, this lining may be removed, and more also, to provide a well of metal to be run down in the cupola before commencing to fill the ladles. It will sometimes be found that, by careful feeding and attention, the bed charge can be made to carry more than the first charge of metal allotted to it in the diagram.

WORKS MANAGER.

A Boring Tool.

A useful form of cutter, which may be easily attached to a boring-bar, is that shown below, and consists of a mild steel shank, *S*, with tapered end, and provided with a cast-steel strip, fastened with a couple of countersunk screws. The strip is set in a diagonal direction, which allows the cutting edge to operate from centre to point. In boring long holes, the bore is first made for a distance of an inch or two with an ordinary tool, and the D-bit is then inserted, soap-suds or oil being used as a lubricant. As a proof of its efficiency, I may say that a hole 39 ft. in length was finished in a most satisfactory manner.

W. P.



BORING TOOL.

The guinea prize was awarded last month for the contribution "Boring Bar for Propellers."

To Principals and Works Managers.

Separate copies of the Workshop Practice supplement to FEILDEN'S MAGAZINE can in future be supplied for the purposes of distribution in quantities of not less than six, at the rate of 1s. 2d. per dozen. Orders should be transmitted direct to the Publisher.

REPLIES TO WORKSHOP QUERIES.

Temporary Repair to a Motor.

I venture to state that the instructions given under the above heading, in your February Number, are quite inadequate; and, being based upon somewhat hazy ideas as to the methods of winding armatures, might, if acted upon, lead to further disaster. "Burnt-out" coils cannot often be found by testing for open circuit, unless the mass of the commutator lug is sufficiently small to permit the heat generated by the defective coil to travel there, and melt the solder, in which case, the position of the fault would be, as it usually is, quite apparent from inspection. Neither are short-circuited coils always earthed; with modern form wound coils and mica lined slots, the reverse is more often the case.

A burnt-out coil may be due either to a short circuit between adjacent commutator segments, or to the failure of the insulating covering on the wire itself, permitting contiguous convolutions to make contact; in both cases, a heavy current flows between the points of short circuit, rapidly heating the conductor and destroying the insulation. The invariable rule for dealing temporarily with a burnt-out coil is as follows:—Disconnect the two ends only of the defective coil from the commutator, and bridge over these two segments with a piece of wire of equal section.

In bi-polar motors, whether ring or drum wound, the ends of any coil will be found in adjacent segments. The same conditions obtain in multi-polar motors, if connected in multiple circuit, that is, with as many sets of brushes as there are poles. This refers to single windings only; in double, triple, etc., windings (uncommon, except in low voltage motors or generators), there would be one, two, etc., segments between those to which the ends of any one coil are connected. Single two-circuit windings in the case of bi-polar, and multiple-circuit single windings in the case of multipolar motors of over, say 5 kilowatt capacity, are practically universal. Smaller multipolar sizes may, however, have a two-circuit winding (either ring or drum), in which case the ends of the coil will be found, in a four pole, at practically opposite sides of the commutator, or 180 degs. apart; with six poles, 120 degs. apart; eight poles, 90 degs., and so on. It should be noted that in two-circuit windings a "short" between adjacent segments, or between the leads from coil to commutator, will affect two coils at diametrically opposite points of the armature; in a four-pole, three coils equally spaced, in a six-pole, etc. A coil short-circuited on itself need not, however, affect any other armature coils connected in series with it, counting from brush to brush.

It is further important to bear in mind that simply disconnecting a burnt-out coil from the commutator does not necessarily prevent the short-circuit current from flowing. Usually, the insulation is almost entirely destroyed, and the coil becomes a solid mass, absorbing power, generating heat, and affecting the insulation of adjacent coils. The only remedy is to sever each and every convolution, and fix so that the two bunches of ends cannot come in contact.

A simple device, not generally known, for detecting a short circuit in an armature winding, and which applies more particularly to new machines, or when starting up after repairs, is as follows:—Energise the field magnets, and carefully and firmly hold a small piece of iron or steel, such as a screw-driver, near the pole tip of one of the magnets. If, now, the armature is started up with ample resistance in circuit, and is in order, no variation of the pull due to the magnetism can be detected. If a short circuit exists, a violent pulsation of the magnetism will be felt every time the defective coil passes the pole tip, owing to the heavy short-circuit current momentarily demagnetising the field. In the case of slot-wound armatures, there is usually a slight rhythmical pulsation due to individual teeth sweeping past the pole tip; but this cannot possibly be confounded with that arising from a short circuit, the pulsation from which, once experienced, is never forgotten.

An open circuit in an armature winding is always characterised by severe sparking or flashing round the commutator, the arc being apparently drawn out from the brush in the direction of rotation. The insulation between commutator segments, to which ends of faulty coil are attached, is gradually eaten away, and if permitted to continue, the commutator will be ruined. Simply bridging across the open space will, in this instance, permit the motor to go on working. It is generally advisable, however, to disconnect the ends of the faulty coil, particularly if either portion of it is earthed; as

under certain conditions of supply, an earth on the motor promptly blows the fuses.

It is to be hoped that the march of progress will render failures of electrical machinery of more and more unusual occurrence. For some time to come, however, "temporary repairs" may often serve an extremely useful purpose if carried out by competent workmen. J. H. H.

REPLY TO W. W.

Worm Gearing.

Let AB be an inclined plane; M a mass resting on it. If the inclination of AB is gradually increased, at a certain angle α, M will begin to slide down towards A. This value of angle α is called the "angle of static friction," and tan α = coefficient of friction. Now, consider the plane wound round a cylinder to form a screw (Fig. 2), and C be the tooth of a worm-wheel pressing on it. Then, if the angle of inclination of the teeth is greater than the angle of friction, as defined above, the wheel can drive the worm. Now, it will be clearly seen that for a given number of threads per inch, the smaller the diameter of the worm the greater will be the angle α, and so where the worm is to be driven it should be as small and have as long a pitch as possible to give good efficiency.

The case where the worm is driving is similar: if the angle β, at which the surface of screw acts on the tooth of the worm-wheel is greater than angle of friction, the screw *can* drive the worm-wheel; if it is less than the angle of friction the screw *cannot* drive the worm-wheel whatever force is applied to turn it. Just as, however great the weight in Fig 1 were made, it would not slide down the plane unless the inclination were greater than the angle of friction. Now, it is clear that for a given number of threads per inch the greater the diameter of the worm the greater will be the angle β, and so, where the screw is driving, it should be of as large diameter and short a pitch as possible to give good efficiency. From this it will be clear that if a worm gear is designed to transmit power efficiently in one direction, it will not be able to be driven in the other. I hope I have made this quite clear, as I have found it is a point which a good many engineers are rather hazy about. The mathematics of the subject may be found in Unwin's Elements of Machine Design," Part I, page 349. B. Sc.

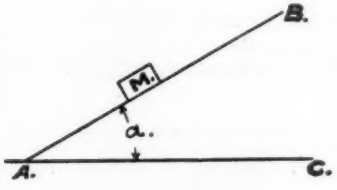
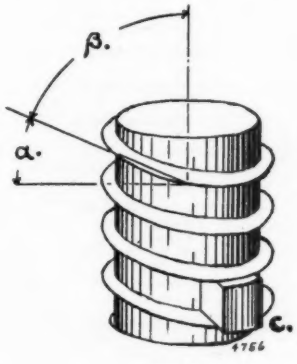


FIG 1.



WORM GEARING. FIG. 2.

Engineering Abstracts

❀ ❀ ❀

LIST OF PUBLICATIONS REGULARLY REVIEWED.

Amer. Engin. & Rlrd. Jnl.	American Engineer and Railroad Journal	New York.....	20 *cts.*
Amer. Machst.	American Machinist	New York	-/4
Amer. Machy.	American Machinery	New York	-/4
Ann. Ing. Gand	Annales de l'Association des Ingénieurs de Gand	Brussels	*f.*2.50
Brit. Archt.	The British Architect	London	-/4
Brit. Claywkr.	The British Clayworker	London	-/6
Builder	The Builder	London	-/4
Bldrs.' Jnl.	Builders' Journal and Architectural Record	London	-/2
Bldng. News ...	Building News	London	-/4
Canad. Imp. Trade	Canadian Implement Trade	.....	...
Canad Mfr. ...	Canadian Manufacturer	Toronto.....	...
Coll. Gdn.	The Colliery Guardian	London	-/5
Coll. Jnl.	The Colliery Journal and Mining Engineer	London	-/6
Com. Intel......	Commercial Intelligence	London	-/3
Compt. Rendu Soc. Ing. Civ.	Compte Rendu des Travaux de la Société des Ingénieurs Civils de France	Paris	*f.* 3.00
Contract Jnl.	The Contract Journal	London	-/6
Echo des Mines et Metall.	L'Echo des Mines et de la Métallurgie	Paris	p.a. *f.*45.00
Elec. Eng.	The Electrical Engineer	London	s.c. -/3 p.a. 13/-
Elec. Rev.	Electrical Review ...	London	-/4
Elec. Rev., N.Y.	The Electrical Review, N.Y.	New York.....	s.c. 10 *cts.* p.a.$5
Elec. Times ...	Electrical Times ...	London	-/2
Elec. Wld.	Electrical World & Engineer	New York.....	s.c. 10 *cts.* p.a.$6
Electrician ...	The Electrician	London	s.c. -/6 p.a. 26/-
Electricien ...	L'Electricien	Paris	s.c. 50 *c.* p a. 25 *f.*
Electricity	Electricity.....	New York.....	s.c. 10 *cts.* p.a. $4'50
Elec. Techr. ...	Der Electro-Techniker	Vienna	60 *kr.*
Engineer	The Engineer.....	London	s.c. -/6½ p.a. 29/-
Engineering ...	Engineering	London	s.c. -/6½ p.a. 29/2
Eng. and Min. Jnl.	The Engineering & Mining Journal	New York.....	...
Eng. Gaz.	The Engineer's Gazette	London	-/6
Eng. Rec.	The Engineering Record	New York.....	s.c. 12 *cts* p.a. $6
Foundry	The Foundry	Cleveland, U.S. A.	p.a. $1
Gas Wld.	The Gas World	London	-/3
Gaz	Le Gaz	Paris	1 *f.*
Gén. Civil	Le Génie Civil.....	Paris	s.c. *f.* 1.00 p.a. *f.*45.00
Ice and Cold Storage	Ice & Cold Storage	London	-/6
Ind. Elec. ...	L'Industrie Electrique	Paris	s.c. *f.* 1.00 p.a. *f.*26.00
Iron and Coal Trades Rev.	Iron and Coal Trades' Review	London	-/6
Iron and Steel Trades Jnl.	Iron and Steel Trades' Journal	London	-/3
Jnl. Gas Lighting	The Journal of Gas Lighting	London	-/6
Jnl. Assoc. Eng. Soc.	Journal of the Association of Engineering Societies	Philadelphia, U.S.A.	...
Jnl. Franklin Inst.	Journal of the Franklin Institute	Philadelphia, U.S.A.	30 *cts.*
Jnl. I. E. E. ...	Journal of the Institution of Electrical Engineers	London	...
Jnl. Iron & Steel Inst.	Journal of the Iron and Steel Institute	London	...

Jnl. San. Inst.	Journal of the Sanitary Institute	LONDON	...
Jnl. Soc. Arts	Journal of the Society of Arts	LONDON	...
Jnl. Western Soc. Eng.	Journal of the Western Society of Engineers	CHICAGO, U.S.A.	...
Knowledge	Knowledge	LONDON	-/6
Light Rly. & Tram. Jnl.	Light Railway and Tramway Journal	LONDON	1/-
Machinery ...	Machinery	NEW YORK.....	25 *cts*
Marine Engr.	Marine Engineer ...	LONDON	1/-
Marine Engg.	Marine Engineering	NEW YORK.....	25 *cts.*
Mech. Wld. ...	Mechanical World	MANCHESTER...	-/1
Métallurgie ...	La Métallurgie	PARIS	p.a. *f.*20.00
Mines and Minerals	Mines and Minerals	.... ..	20 *cts.*
Mit. Verein. Strassenbahn.	Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnvesens	VIENNA	...
Mod. Machy.	Modern Machinery	CHICAGO	10 *cts.*
Nat. Ldry. Jnl.	National Laundry Journal	CHICAGO	15 *cts.*
Nature	Nature	LONDON	-/6
Power	Power.....	NEW YORK.....	20 *cts*
Proc. Am. Soc C.E.	Proceedings of the American Society Civil Engineers	NEW YORK.....	..
Proc. Inst. C. E.	Proceedings of the Institution of Civil Engineers	LONDON	...
Proc. I. Mech. E.	Proceedings of the Institution of Mechanical Engineers	LONDON	...
Proc. Roy. Phil. Soc. Glasgow	Proceedings of the Royal Philosophical Society of Glasgow	GLASGOW	...
Pub. Health Eng.	Public Health Engineer	LONDON	-/3
Quarry	The Quarry.....	LONDON	-/6
Rlrd Gaz.	The Railroad Gazette	NEW YORK.....	p.a. $6'08
Rly. Age	The Railway Age ...	CHICAGO	10 *cts.*
Rly. & Eng. Rev.	The Railway and Engineering Review	CHICAGO	10 *c.*
Rly. Mastr. Mech.	Railway Master Mechanic	NEW YORK ...	s.c. 10 *cts.* p.a. $1'00
Rev. Chim. Ind.	La Revue de Chimie Industrielle	PARIS	p.a. *f.*12.00
Sc. Amer.	Scientific American	NEW YORK.....	8 *cts.*
Stahl u. Eisen	Stahl und Eisen.....	DÜSSELDORF ...	p.a. 24 *mks.*
Steamship	The Steamship	LEITH	-/6
Stev. Inst. Indic.	Stevens' Institute Indicator	HOBOKEN, N.J.	50 *cts.*
Street Rly. Jnl.	Street Railway Journal	NEW YORK.....	s.c. 50 *cts.* p.a. $6.00
Surveyor	Surveyor	LONDON	-/3
Tram. & Rly. Wld.	The Tramway and Railway World	LONDON	1/-
Trans. Am. I. E.E.	Transactions of the American Institute of Electrical Engineers	NEW YORK.....	...
Trans. Am. Soc. Mech. E.	Transactions of the American Society of Mechanical Engineers	NEW YORK.....	...
Trans. Am. Soc. Nav. E.	Transactions of the American Society of Naval Engineers	NEW YORK.....	...
Trans. Inst. Eng. & Shi bldrs.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	GLASGOW	...
Westn. Electn.	Western Electrician	CHICAGO	10 *cts.*
Zeitschr. Vereines Oster. Ing. und Arch.	Zeitschrift des Oestereichischen Ingenieur und Architekten-Vereins	VIENNA	60 *hr.*
Zeitsch. Elektrotechnik.	Zeitschrift für Elektrotechnik	VIENNA	p.a. 20 *mks.*
Zeitsch. Elektrochemie	Zeitschrift für Elektrochemie	HALLE À S., GERMANY	4 *mks* per qr.

Any of the above-mentioned publications can be obtained on application to Messrs. Williams & Norgate, Henrietta Street, Covent Garden, London, W.C.

MATERIALS AND MEASUREMENTS.

A Transmission Dynamometer.

THE instrument here described is intended to be fixed to the pulley on the line or counter shaft and it may be left there as long as required for tests, without disturbing the operation of the machine under test, either while readings are being taken or during any intervals. As described, the appliance is only suitable for light loads, and when required for heavy loads a known auxiliary weight may be hung from some point of the arm, or spring balances may be attached side by side. Supposing it is desired to ascertain the power taken from the line shaft for driving a certain machine, and assuming this shaft makes 260 revolutions per minute, if the arm of the dynamometer is held fast, the pulley making 200 revolutions will cause the arm to rotate left-handed about the shaft at 100 revolutions per minute. After suitable adjustment to make the arm stand at right angles to the spring balance on the apparatus the load is read off. Assuming this to be 130 lbs., the horse power will be:

$$H.P. = \frac{\text{Veloc. in ft. per min.} \times \text{load in lbs.}}{33{,}000}$$

$$= \frac{100 \times 12 \times 130}{33{,}000} = 4{\cdot}73$$

If the speed is constant, the power varies directly as the reading of the spring balance, in which case a paper scale graduated to read in horse-power can be pasted on the balance.—**F. S English,** *Amer. Machst., Feb. 28, 1903,* pp. 225–226.

The Weight of Solids of Revolution.

THE author describes and illustrates an ingenious device for the automatic computation of the weight of castings. In this simple contrivance, a pine stick, 20 ins. long by $\frac{1}{4}$ in. by $\frac{1}{16}$ in., is pivoted at the centre (a) upon a needle driven into the wall, and the ends of the stick are whittled until it will stand indifferently in any position. At one end of the stick a piece of pasteboard, representing the generating section of the solid to be produced, is slid on through slits cut with a penknife, and at the other end a second piece of pasteboard (b), of known area, is similarly attached. The known area of $(b) = 1 \div (2\,\pi\,m\,n)$, where m = weight in lbs. of one cubic inch of material, n = length corresponding to 1 lb. on arm $a\,b$. The axis of the generation section must pass through the needle, and both pasteboards must be cut from the same sheet to insure uniformity in thickness, but the size of b may always remain the same for any material and scale. Should it be required to produce a steel armour-piercing projectile weighing 899 lbs., the distance $a\,b$ must be 8·99 ins., and if the pasteboard generating section does not balance the pasteboard area b, its area must be altered until it does so. The size of b, for the projectile is determined as follows, the drawing being, say, one-third full size: $n = \frac{1}{100}$ in. actual $= \frac{3}{100}$ in. measured with a one-third scale, $m = {\cdot}283$, $b = 1 \div (2\,\pi\,m\,n) = 1 \div (2 \times \pi \times {\cdot}283 \times \frac{3}{100}) = 18{\cdot}75 = 5 \times 3\frac{3}{4}$ measured with the one-third scale.—**G. F. Summers,** *Amer. Machst., Jan. 31, 1903,* p. 91.

CONSTRUCTIONAL.

British Standard Sections.

LIST 1.—*Equal Angles:* Sizes from 1 in. by 1 in. to 8 ins. by 8 ins.; minimum, mean, and maximum thicknesses for different sizes. Angles may be rolled of any thickness between, above, or below the standards, and should be ordered by width of flanges and thickness, or by width of flanges and weight per foot, preferably by the latter method.

List 2.—*Unequal Angles:* Sizes from $1\frac{1}{2}$ in. by 1 in. to 10 ins. by 4 ins.; minimum, mean, and maximum thicknesses for different sizes. May be rolled of any thickness between, above, or below the standards, and should be ordered by size of flanges and weight per foot.

List 3.—*Bulb Angles:* Sizes from 4 ins. by $2\frac{1}{2}$ ins. to 12 ins. by 4 ins.; one thickness for both web and flange, and one for bulb of each size. If thickness rolled is greater than standards, the width of flange and bulb and depth of web will be increased. Generally for each 0·05 in. increase or decrease in thickness of web the thickness of flange will be increased or decreased 0·025 in. Should be ordered by depth of web, width of flange, and weight per foot.

List 4.—*Bulb Tees:* Sizes from 7 ins. by 5 ins. to 12 ins. by $6\frac{1}{2}$ ins.; one thickness each for web, flange, and bulb of each size. If the thickness is less or greater than standards, the thickness of web and widths of bulb and flange will be similarly altered. To be ordered by depth of web and weight per foot.

List 5.—*Bulb Plates:* Sizes from 6 ins. to 12 ins.; one thickness each for plate and bulb of each size. If the thickness of web is altered, the thickness of the bulb will be similarly altered. Should be ordered by depth of web and weight per foot.

List 6.—*Z-Bars:* Sizes from 3 ins. by $2\frac{1}{2}$ ins. by 3 ins. to 10 ins. by $3\frac{1}{2}$ ins. by $3\frac{1}{2}$ ins.; one thickness each for web and flanges of each size. If thickness is greater than standards, the length of web and flanges will be proportionately increased. Generally for each 0·05 in. increase in the thickness of web the

flange will be increased 0·025 in. Should be ordered by depth of web, width of flanges, and weight per foot.

List 7.—*Channels:* Sizes from 3 ins. by 1½ in. by 1½ in. to 15 ins. by 4 ins. by 4 ins.; one thickness each for web and flanges of each size. If thickness is greater than standards, the thickness of the web and the width of flanges will be proportionately increased. To be ordered by size of web and flanges and weight per foot.

List 8.—*Beams:* Sizes from 3 ins. by 1½ in. to 24 ins. by 7½ ins.; weights per foot, 4 lbs. to 100 lbs.; one thickness each for web and flanges of each size. If thickness of web is less or greater than standards, the width of section will be increased or decreased by the same amount. Should be ordered by depth of section, width of flanges, and weight per foot.

List 9.—T-*Bars:* Sizes from 1 in. by 1 in. to 7 ins. by 3½ ins.; one thickness each for web and flange of each size. The standard thickness shall be measured at a distance half-way between the extreme edge of the flange and the nearer side of the stem. All tees should be ordered by width of flange, depth of section, and weight per foot. The taper of 1 deg. to be divided equally between the web and flange.—*British Standard Sections, issued by the Engineering Standards Committee, Feb. 1903.*

[NOTE.—Tables will be issued at a later date giving the areas of sections in square inches, weights per foot run, moments of inertia, and other data.]

Sand-Blast Cleaning of Structural Steel.

THIS paper sets forth some of the results attained by the use of the sand-blast in cleaning steel plates and structural steel. Data as to the cost and other elements which enter into its application are presented, so that assistance may be afforded for the preparation of approximately accurate estimates of the cost of any sand-blast cleaning contemplated. Some work heretofore done was published in the *Engineering News* of April 24th, 1902, when the cost of cleaning 12,600 sq. ft. of the viaduct over the Little Miami Railroad, in Columbus, Ohio, was stated. The author now presents the experience gained in the continuance of the work during 1902, giving results in cleaning a total area of 135,500 sq. ft. on viaducts in that city, which have been repainted since the early part of November, 1901. Several types of apparatus are described and illustrated, photographs are given of corroded metal, and the methods of procedure followed are set forth. The following table shows the cost as ascertained from the sand-blast cleaning of viaducts at Columbus:—

Location of Viaduct.	Cost of labour.	Cost of flagmen.	Sand used.		Cost of compressed air.	Dryer, sand-blast, scaffolding, etc.	Total Cost.	No. of sq. ft. cleaned.	Cost per sq. ft.	Sq. ft. cleaned per cub. ft. sand.	Sq. ft cleaned per hour by one sand-blast	Average pressure of sand-blast lbs. per sq. in.
			Cub. yds.	Cost.								
Front Street — Little Miami Railroad ...	$385.30	$45.15	54.00	$78.55	$139.40	$56.68	$705.08	24,900	$0.0283	17.1	64	35
Naghten Street — do.	140.74	17.85	28.44	42.41	56.40	32.52	289.92	8,000	0.0362	10.4	49	37
Maple Street — do. ...	223.00	11.90	34.50	58.08	94.80	58.70	446.48	17,000	0.0263	18.2	66	35
Front Street — Pittsburg, Cincinnati, Chicago, and St. Louis and Cleveland Railways ...	670.66	—	92.65	107.43	229.80	87.18	1,095.07	63,000	0.0174	25.2	89	30
High Street—do. ...	951.20	—	129 91	161.47	319.94	122.46	1,555.07	22,600	0.0688	6.1	23	33
Totals and averages	$2,370.90	$74.90	339.50	$447.94	$840.34	$357.54	$4,091.62	135,500	$0 0302	14.8	54	33
Excluding High St. Viaduct ...	—	—	—	—	—	—	2,536.55	112,900	0.0225	20.0	74	33

—**G. W. Lilly,** *Proc. Am. Soc. C. E., Vol. XXIX., No. 2,* pp. 130-152.

Wooden Beams and Columns in Street Railway Bridge Construction.

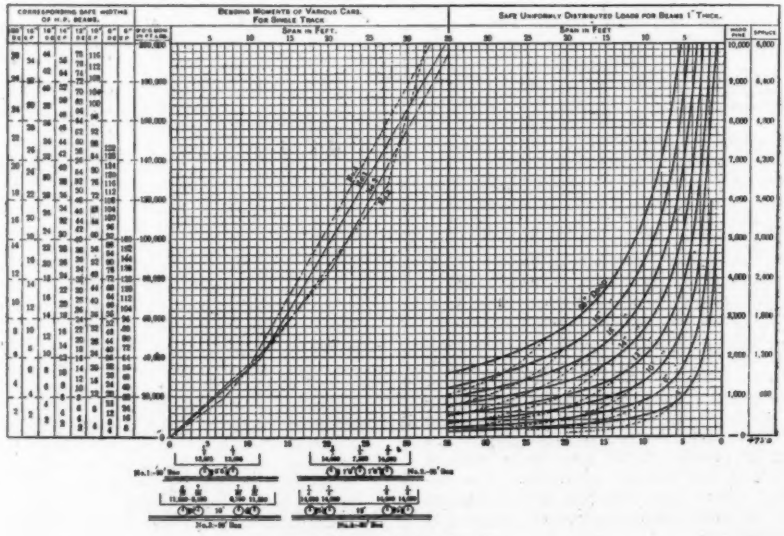
THE accompanying diagram and information will be found convenient for determining the requisite size of timbers for various spans and loads. On the diagram at the left are shown curves representing the bending moments for single track of various types of cars, including their estimated maximum loads. The horizontal spacing represents the span in feet, and the vertical spacing the bending moment in foot-pounds. At the left, in the several vertical columns, are shown the widths of Southern pine timber for various depths to support the load causing the bending moment opposite. If in any case on short spans it is necessary to use spruce, multiply the figures representing the widths by 5/3. On the diagram at the right are shown, by full lines, curves representing safe uniformly-distributed loads for different depths of sticks, 1 in. wide, the columns to the right giving safe loads for both spruce and Southern pine. The dotted lines limit the deflection to 1-240 of the span; no greater deflection should be allowed in permanent work, although for temporary work values obtained from the full line may be used. This diagram does not apply on building construction, where deflection should be limited to 1-480 of the span. These diagrams have been based on the usual formula:

$$\frac{Wl}{8} = \frac{bd^2S}{6},$$

For the value of S, 1250 lbs. has been used for Southern pine and 750 lbs. for spruce. This gives a factor of safety of about 4. In calculating the deflection curves, a modulus of elasticity of 750,000 was used. Although values are given for any span up to 35 ft., it is not advisable or economical to use plain beams for a span of more than 20 ft. In addition to the information given in connection with the diagrams, formulæ are given showing the safe supporting power of wooden columns.—**H. B. Andrews,** *Street Rly. Jnl., Vol. XXI., No. 8, Feb. 21, 1903* p. 298.

Tunnel Construction under Water.

IN the course of some informal remarks at a meeting of the Boston Society of Civil Engineers, Mr. Howard A. Carson gave a great deal of information relative to the East Boston Tunnel, which is 3,500 ft. long, 23 ft. to 24 ft. wide inside, the arches and sides are 30 ins. thick, and the invert about 2 ft. thick. The advance excavation consists of two side wall drifts solidly timbered, and kept from 60 ft. to 150 ft. ahead of the shield, so that the walls built in them to about 16 ins. below the springing line of the arch, will be at least


CORRESPONDING SAFE WIDTHS OF N.P. BEAMS.
BENDING MOMENTS OF VARIOUS CARS. FOR SINGLE TRACK
SAFE UNIFORMLY DISTRIBUTED LOADS FOR BEAMS 1" THICK.
SPAN IN FEET.
SPAN IN FEET
WOOD PINE
SPRUCE

WOODEN BEAMS AND COLUMNS.

ten days old when the shield reaches them. The shield, resting on rollers, passes along on the side walls, and the main excavation is done under the shield. The hydraulic jacks for pushing the shield react against cast-iron rods, continuously imbedded in the concrete of the arch, which is turned on 4-in. lagging supported by steel ribs 2 ft. 6 ins. apart. At present air-pressure in advance of the air-locks is about 23 lbs. above the atmosphere. There are three air-locks, two for materials and one for workmen. At present the earth between the bottom of the harbour and the top of the tunnel is 18 ft. thick, but after dredging there will be only 5 ft. The depth of water from the surface to the bottom of the tunnel is about 88 ft. The East Boston tunnel progress was as follows: for the first six months in clay, an average of 3 ft. per day; the next six months, over 4 ft. per day; and for the next, over 5 ft. per day. Mr. Carson also made reference to the systems of tunnelling adopted in connection with the Paris Metropolitan Subway, the City and South London Railway, the Glasgow Cable-way, the Central London Railway, the City and Waterloo Railway, the tunnels under the St. Clair and Hudson Rivers, and the Black-wall Tunnel. He then described the method of laying the syphon under Shirley Gut and the sewer outfall, both at Boston. The Shirley Gut pipes were made of iron and brick, from 50 ft. to 65 ft. long by 9 ft. to 10 ft. diameter; each length had light bulkheads at each end; and having been floated over the place they were to occupy, were sunk to the bottom and bolted together by divers. The sections for the Deer Island outfall were made of concentric rings of concrete and brick, with wooden staves to protect the masonry. These sections were built in cradles, placed at the side of a wharf, and each weighed about 220,000 lbs. They were lowered by screw bolts by means of an engine, and were towed out to their proper position, sunk on saddles, and connected by divers. The joints between consecutive pipes, both at Shirley Gut and at the outfall, were made tight by rubber gaskets. The bulkheads were removed at a later time, and the brickwork was then made continuous. In the discussion following, Mr. Rice gave an account of the Haarlem River pipes of the New York rapid transit system.—**H. A. Carson,** *Jnl. Assoc. Eng. Soc., Vol. XXIX., No. 6, Dec. 1902.*

TRACTION.

Brake Tests.

THE author of this paper gives a brief account of the methods used by him in determining for an electric traction company the relative merits of several types of power-brakes. In all tests the same type of car was used, mounted on similar trucks, put in as nearly the same condition as possible, and loaded to the same gross weight by an amount equal to a heavy passenger load. The cars were run in the same direction over the same section of track on a uniform grade, and great care was taken to determine the speed of the car at brake-signal, and the actual distance traversed between brake-signal and stop. An axle of the car was fitted with a drum carrying a contact plate, which once in every revolution closed a battery circuit; this circuit energised an electro-magnet operating one of two recording pencils, under which a strip of paper was drawn at uniform speed by a very carefully-adjusted spring-motor. The operating magnet of the other pencil was energised by a circuit closed every half-second by a contact-maker actuated by a carefully-adjusted clock movement. With this apparatus a record-sheet was obtained, giving a clear record of wheel revolutions, and showing with great accuracy the number of revolutions during any interval of time, or the duration of any particular wheel revolution. Using this method, the author made a large number of tests on various types of brake, the results of which are tabulated in the paper. He has also evolved an empirical equation showing the operation of these brakes under different conditions, the coefficients in the equation being derived from the tests. One practical result of the tests was the application by the author of differential levers to hand-brakes; another was a similar application to one type of power-brake. By the use of non-equalising levers, applying to the front truck a braking pressure exceeding that applied to the rear truck in a certain predetermined ratio, the distance required to stop a car with a certain power-brake was reduced by approximately 18 per cent.—**J. D. Keiley,** *Trans. Am. Inst. E. E., Jan. 1903,* pp. 13-27.—*H.*

Motor Cars and Railways.

THE railway companies, by an intelligent use of the automobile, could assist their own traffic and avoid much wasteful competition. The railway companies within a radius of a few miles of such places as Brighton, Basingstoke, Didcot, Epsom, St. Albans, etc., should arrange to collect their passengers by motor car as they now collect goods by vans and horses. A well-filled passenger train pays the railway companies equally well, some experts think rather better, than a goods train, and while the companies would send a van to fetch a passenger's hatbox, and be responsible for

its arrival at a particular destination, charging an inclusive rate, they will not collect him or take any steps to assist him in getting to his terminal station or deliver him when he arrives at his destination. Passengers living geographically near London are often as far off in point of time as passengers living at two or three times the distance, owing to it not being worth while for the railway companies to build branch lines for small groups of population. Motor car services should in such instances be instituted for early morning and evening passenger service, and, if built on suitable lines, used for the conveyance of light parcel traffic during the rest of the day. Motor cars might be run in connection with express trains stopping at principal stations. At present, principal stations are merely centres from which passengers have to change from the fast trains to local lines. If the railway companies do not encourage and foster every possible means of inducing travellers to journey by their systems, plenty of other people, notably the electric tramway companies, will undoubtedly take up the matter and thereby damage the suburban receipts of the trunk lines. By the adoption of motor cars at suitable stations for dealing with the local passenger traffic additional opportunities for through bookings would probably increase the receipts of the railways, as the tourist could be booked straight through to places of intetest. With reference to certain branch lines which undoubtedly do not pay, a motor-car service should be substituted and even in some cases they should be boldly made into motor roads by bringing the material on the road bed up to the level of the rails. A motor car running on such roads would have no speed limits, and could prolong its journey beyond the present terminal station. In regard to goods traffic, under the present system the cost of distribution and collection in London is enormous, and the goods van mileage compared with the weight of goods carried is ridiculous. Motor vans could cover much greater distances at less expense, and be working continuously. Before long motor lurries should be taking freight and merchandise to big goods stations outside the metropolitan area, thereby rendering available the enormously valuable sites at Euston, Nine Elms, etc., for other purposes. The companies should be warned by the competition of electric tramways, which have already been the cause of stations being absolutely closed on the North Eastern Railway near Newcastle, and the North British Railway near Glasgow. The North-Eastern have already, through the force of this competition, ordered automotor cars. The South-Western are also on the eve of running some steam automotor carriages on the branch line between Fratton and Southsea, whilst in France Serpollet steam cars are being constructed for the Paris-Lyons-Mediterranean Railway.—**The Hon. J. Scott Montagu :**—*The Automotor Journal, Feb. 21, 1903*, pp. 208-9.

Marseilles Electric Tramways.

THIS paper describes the chief features of the generating plant and of the system for the distribution of energy to the tramways of Marseilles, (1) the distribution of tri-phase current at high tension, with substations at St. Giniez, Castellane, Rue Sénac, Rue d'Anvers et Lazaret, transforming tri-phase current to continuous current at 550 volts: (2) the power-house with twenty boilers, five 1,000-kilowatt alternators furnishing tri-phase current at 5,500 volts, three 80-kilowatt dynamos furnishing continuous current at 110 volts, and (3) the general scheme of distribution.—**H. Dubs,** *Bulletin de la Soc. Scientifique Industrielle de Marseille, 1901*, pp. 180-183.

The Most Economical Speeds for Goods Trains.

FOR the conduct of goods traffic upon an economical basis it is necessary to utilise to the fullest extent the tractive power which the rolling stock is capable of furnishing. The conditions of load and speed must approach as closely as possible to the limit determined by the maximum power of the locomotive. With these preliminary observations, the writer introduces a line of argument and a series of equations showing the relation of cost to load, speed, and time, and giving expressions —(1) for E, the resistance of the entire train ; (2) for F, the tractive effort exerted by a locomotive ; (3) for the tractive effort, as qualified by the condition of adhesion ; and (4) for the mean speed of a run in kilos. per hour, as determined by a combination of equations (2) and (3). The inference is drawn that for every type of locomotive there is a minimum limit, below which speed should not be allowed to fall for fear of skidding. The use of sand affords a momentary remedy for want of adhesion, but it must be regarded merely as a temporary expedient for cases of emergency. Under normal conditions of running the writer considers the minimum speed must be 10 kilos. per hour. Two important equations evolved from the reasoning mentioned are the following :

$$P = \frac{1{,}000\ C}{\sqrt{V}\,(2{\cdot}5 + 0{\cdot}001\ V^2 + i)} - P_1 \qquad (5.)$$

where P = load hauled in tonnes ; P_1 = weight

of locomotive and tender in tonnes; C=a constant varying with each type of locomotive; V=mean speed per run in kilos. per hour; and i=the gradient in millimetres per metre. Multiplying the two portions of the above equation by V, the value of PV is represented in tonne-kilos. per hour. Thus:

$$Y = PV = \frac{1{,}000\, C\sqrt{V}}{2{\cdot}5 + 0{\cdot}001\, V^2 + i} - P_1 V \quad (6.)$$

A third equation (7) is given, bearing upon the most advantageous value for V, but it does not permit the direct calculation of such value, which has to be determined by successive approximations. The solution of the problem is simplified in each particular case by the use of diagrams. The author proceeds to give two examples, showing the application of his method to the cases (1) of a railway line of constant gradient, and (2) of a railway line of variable gradient. The equations (5) and (6) are represented by curves for the case of the locomotive selected by the author, and it is easy to read off from the diagram the values of the load P corresponding to the most economical speeds upon the gradient stated, assuming the maximum and continuous utilisation of the tractive power available. The second case is not quite so simple, as the curves drawn for case (1) do not apply. The problem is resolved by a series of approximations, an example of which is given in the article. Thereby the author ascertains for the case assumed the most economical load that may be drawn, and the speeds that should be attained on each section of the line.—**F. Barbier,** *Gén. Civil, Vol. XLI., No. 16,* pp. 247, 248.

LIGHTING, HEATING, and VENTILATION.

The Nernst Lamp.

TWO types of this lamp are now in use, one of which (*A*) has burners for 1 amp. up to 250 volts., and for ½ amp. from 200 to 250 volts. The metal hood is fitted with combs of sheet copper for the purpose of cooling the "bolstering" resistance, and a number of tubes are furnished between the inner tube and outer mantle for ventilation and for assisting the radiation of heat. The later form of lamp (*B*) is made for ¼ and ½ amp. up to 150 volts, and for ¼ amp. up to 250 volts. The bolstering resistance is made of iron wire, enclosed in a glass globe, which has been exhausted and afterwards charged with hydrogen. Iron has been adopted owing to its high temperature co-efficient, and in practice it is found that if the current increases by about five per cent. the resistance of the wire increases 75 per cent., thus affording a safeguard for the filament. As the resistance of the iron wire does not increase in strict proportion, the sectional area of the bolstering resistance is decided so that the wire may be heated to a critical temperature under the conditions intended for each size of lamp. The author refers to various tests already published as to the efficiency and life of the Nernst lamp, and points out that many errors are committed in its treatment, but he adds that if the instructions for use are carefully followed a life of from 300 to 400 hours may be anticipated. One great mistake generally made is to send the current through the lamp in the wrong direction, particularly in type *B*. Another mistake is to overrun the lamps, and as the surplus current is taken up by the bolstering resistance the light is not the least increased.—**J. Stottner,** *Meeting I. E. E. Paper, read Feb. 26, 1903.*

Comparative Cost of Street Lighting.

IN order to compare the price that New York pays for electric and gas lighting with the prices in other cities, returns were procured from 175 cities of from 25,000 to 1,600,000 inhabitants. It is noticeable that neither the cost of coal, number of lights, nor length of contract have any comparative effect on the prices paid. New York, using 4,748 arc lamps, pays 125 dols. to 146 dols., each, while Evansville, Ind., with 300 lamps, pays 60 dols. In Chicago it costs 53 dols. 51 cents to produce a 2,000-c.p. arc light, running all night and every night, this charge including cost of new material and repairs. In the last 16 years Chicago has expended 3,400,663 dols. for lighting the city and for building its own plant, whereas if it had purchased from private companies during that period the expenditure would have been 3,535,875 dols. If the price at which Chicago furnishes light were doubled it would still be nearly 40 dols. per lamp below the price now paid in New York. The result of the returns from from the first hundred cities, relating to gas as well as to electric light, are given in tabular form in the report recently made by Mr. Charles F. Lacombe, to the Commissioner of water supply, gas and electricity, New York. —*Eng. Rec., Vol. XLVII., No. 12, March 21 1903,* pp. 295-6.

An Electric Car Lighting System.

THIS article commences the description of an axle-driven electric car lighting system in which the generator is located on the truck frame, the armature being rotated by means of a single reduction gearing. Explanation is given of the mechanical construction of the generating apparatus and the method of controlling the electrical energy

under all conditions of railway service. The system consists essentially of the following elements:—(1) A dynamo or generator located on the car, or, as is the common practice in this country, directly on the truck frame, and so arranged that its armature is caused to rotate by means of a mechanical connection with the axle. (2) Translating devices within the car consisting in general of incandescent lamps and fan motors, which utilize the electrical energy developed in the generator. (3) A storage battery carried on the car, whose special function is to supply the electrical energy necessary to operate the lamps whenever the armature of the generator revolves at a speed too low to render the same operative, or when the armature ceases to rotate, which condition is obviously attained when the car is at rest. (4) Auxiliary automatic apparatus, which, acting in conjunction with the above, will render the operation of the entire system automatic, safe, and reliable.—**W. L. Bliss,** *Elec. Rev., N.Y., Vol. 42, No. 10 March 7, 1903,* pp. 338-342.

POWER AND TRANSMISSION.

Bedell System of Composite Transmission.

FOR the transmission of mechanical power, polyphase currents are required, and a low frequency is desirable, while for lighting services high frequency is required, and, as regards the receiver, the equivalent of single-phase circuits must be used. The Bedell system provides for the simultaneous transmission, within the same conductors, of low-frequency polyphase currents for mechanical power and high-frequency polyphase currents for illumination. Upon the fact of the non-interference of superposed asynchronous currents depends the practicability of the system in question. The diagram shows circuits so interconnected as to obtain the advantages of joint transmission both in the high-tension primary mains, and in the low-potential secondary distributing circuits. Current from the single-phase generator passes differentially through each half of each of the high-potential line transformer coils, consequently the core is unaffected by the flow of the single-phase current. The low-frequency power current does not interfere with the asynchronous current in the transmission line. Hence, the single-phase power is transmitted over the four conductors, in all respects as though the polyphase generating and receiving apparatus were idle. At the receiving station the single-phase current is delivered at the two neutral points of the separate line transformers, and passes into the lowering transformer where, being converted to the proper e.m.f., it supplies energy to the network of feeders for the lamp service. The only change from standard high-tension transmission practice in the polyphase equipment is in the use of two-phase in place of three-

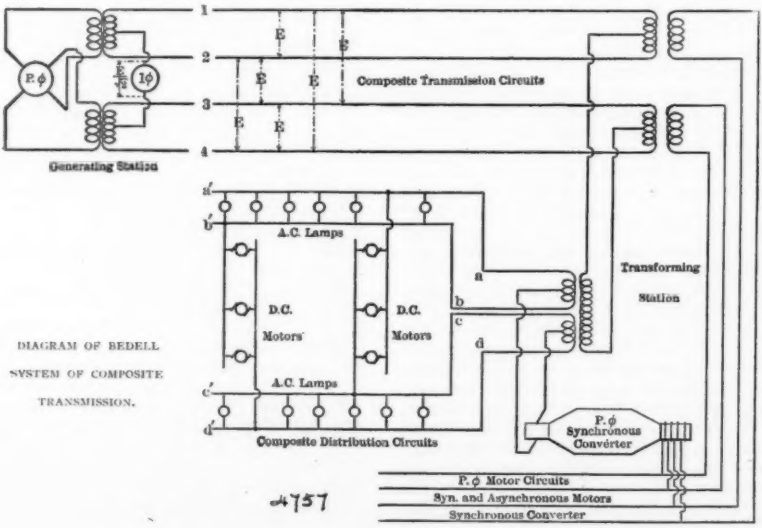


DIAGRAM OF BEDELL SYSTEM OF COMPOSITE TRANSMISSION.

phase circuits, all apparatus intended to be operated by the low-frequency current being of standard design. Motors of the synchronous or asynchronous type, or synchronous converters, are operated by the usual methods. The substitution of two-phase for three-phase current requires one-third more conducting material, but as a set-off the composite system will transmit one and one-eighth times as much power as the three-phase system, in addition to securing independence of regulation of the e.m.f., for lamps and motors, and equality of division of loads on the polyphase system, besides permitting the selection of frequencies adapted to the best operation of each type of machine. The diagram shows the method followed for low-tension secondary distribution, the direct current obtained from the direct-current side of a two-phase synchronous converter being introduced at the neutral points of the two distributing circuit coils of the lowering transformer on the single-phase lighting system. The diagram also indicates polyphase motor circuits for works, where large amounts of mechanical power are used. The Bedell system is equally suitable for incandescent circuits, and for numerous interconnections, of which those mentioned are but isolated examples. —**A. S. McAllister,** *Elec. Wld., Vol. XLI., No. 9, Feb. 28, 1903,* pp. 351-353.

Power from the Blast Furnace.

FOR the present purpose it is not necessary to follow out the reactions which constitute the process of smelting, except in so far as is necessary to determine with some degree of accuracy the quantity and quality of gas produced in the blast furnace. Based on a given analysis of coke and pig-iron, the writer calculates the average consumption of coke per ton (2,240 lbs.) of pig-iron to be 2,000 lbs. The total weight of gas produced in a blast furnace per ton of pig-iron is then calculated and found to be 10,589·62 lbs., obtained from eight sources—viz. solid carbon gasified by oxygen from the blast and from the ore, carbon derived from the metals and metalloids smelted, oxygen from ore and flux, oxygen from the blast, nitrogen from the blast, hydrogen from the blast, methane from the coke, water vapour from the coke. The calorific power of the gas is estimated at 1,283·09 B.T.U. per lb. of gas, or 13,587,330 B.T.U. for every ton of iron made. Allowing for leakage and radiation, it is calculated that 1,884·38 lbs. of gas will be required to heat the blast for 1 ton of pig-iron, leaving 8,705·24 lbs. of gas available for utilisation. Although the application of blast-furnace gas to internal combustion engines is of comparatively recent date, its practicability has already been demonstrated on a commercial scale, and there are to-day upwards of 175,000 h.p. of blast-furnace gas engines in successful operation and in course of erection in Europe, principally in Germany. From a large number of tests it has been found that 25 per cent. of the heat energy in the gas can be realised in effective power. Hence as 1 lb. of furnace gas equals 1,283 B.T.U., fully 1,097·76 h.p. may be developed per ton of iron produced per hour. The power legitimately required to operate the furnace plant should be below 200 h.p. per ton of iron per hour; but allowing 250 h.p. for blowing engines, pumps for all purposes, for handling raw material and product, and for lighting, there still remains 847·76 h.p. for sale, or available for useful work, for every ton of iron produced per hour.—**E. A. Uehling,** *Stev. Inst. Indic., Vol. XX., No. 1, Jan. 1903,* pp. 1-13.

Shafting Hints.

THESE illustrated notes are intended for the guidance of those called upon to fix shafting in buildings. Suggestions are made for lining shafting under the following conditions:—(1) To line a countershaft parallel with the driving shaft when the end centres are available for measurements. (2) When an end centre is not available, or where there is no clear space on the main shaft opposite an end centre. (3) When the shaft is so driven from one end that its other end runs beyond the reach of the driving shaft. Two methods are suggested for getting a line on the ceiling in parallel with the driving shaft, and various practical hints are given upon the fixing of hangers to timber and steel beams.—**Charles Herrman,** *Power, Feb., 1903,* pp. 67-70.

Lightning Protectors for High-Tension Cables.

FOR the efficient protection of high-tension lines, the lightning protectors employed must always be capable of permitting the flow to earth of all atmospheric discharges, and must not absorb any part of the energy generated by the dynamos. Protectors of the make-and-break and bascule types do not realise the first condition, and those of the rheostat type do not comply with the second. With other types of lightning apparatus generally employed for high-tension circuits, it is found that part of the discharge is directed against the line to be protected, and it is useful to interpose a self-induction coil, especially if the electrical machines are deficient in self-induction. The judicious employment of different types of lightning protectors makes it quite possible

to protect a high-tension installation in a satisfactory manner, but it must be remarked that the number and position of these appliances must be suitably chosen, and various precautions must be taken in the general design of the system. With the object of obviating the disadvantages attending the employment of ordinary types of lightning protectors, a new system has been devised by MM. Schoen and Felix. The apparatus consists of a series of elements, each formed of two metallic parts, mounted upon a support and connected together at their upper extremities by a copper conductor in the form of an inverted V. According to the tension of the line to be protected the number of these elements is varied, and the elements with their supports are fixed upon porcelain or other insulators. For tensions above 5,000 volts a double series of insulators is preferably employed. Each of the end elements carries a connector, so that at one end of the series the element is connected to earth, either directly or through a rheostat, and at the other end the element communicates on the one hand with the transmission line, and on the other with the switchboard and the apparatus to be protected. A self-induction coil is interposed between the latter appliances and the lightning protector, the object of the coil being to arrest atmospheric discharges, of which the frequency is always high. The current from the alternators, of which the frequency is relatively low, traverses the coil without appreciable drop of voltage. The apparatus may be fitted in the interior of a generating station upon supports attached to the wall, or upon the summit of the posts carrying an outside cable. In the opinion of the writer this lightning protector is well designed, and constitutes a considerable improvement upon apparatus of the kind already in use. —**Mons. A. Bainville,** *L'Electricien, Vol. XXV., No. 631, Jan. 31, 1903*, pp. 65-67.

IRON AND STEEL.

The Taylor-White Steel-Tool Process.

About three years ago an extensive series of experiments was undertaken at the Bethlehem Steel Works to determine the relative efficiency of various brands of tool-steel. Having decided upon a brand of steel, tools were forged and heated to different temperatures and then put in a lathe and tested. It was found that those cooled from a very high temperature gave remarkable results, far surpassing anything previously accomplished. These tests marked the beginning of a most thorough series of experiments, the object being to determine the best chemical composition and temperature for treating. It is claimed on behalf of the Taylor-White process that the invention relates to the manufacture of tools for cutting metals where the tool is highly heated in performing its work, the object being to provide a tool capable of working at higher temperature, and consequently doing more work in a given time than tools as heretofore made. Thus the tool is only adapted to "roughing" work, and unless sufficient speed can be obtained no gain will result. One of the chief claims made by the inventors is the great uniformity obtained, which makes it possible to run every tool to a very high efficiency. In order to verify the statements made in the patent specifications with regard to increased efficiency at high speeds, and to investigate the process generally, the writers of this report made a series of tests upon various brands of air-hardening steel. They decided to run the tools at the same depth of cut and feed, varying the speed in order that each tool should last twenty minutes. Out of twenty-three tools only thirteen lasted to the completion of the test, and five of these are marked "gone" in the table of results. The best result was given by a Taylor-White tool, which showed a cutting speed of 156 ft. per minute, with $\frac{5}{16}$-in. cut and $\frac{1}{16}$-in. feed. This tool was removing metal at the rate of 353 lbs. per hour, and was *red-hot* $\frac{5}{16}$ in. from the point. The colour was distinctly visible in the daylight, no stronger proof being needful of the high heat at which these tools maintain their cutting edge. At the end of twenty minutes the edge of the tool was carefully examined with a magnifying glass and found to be perfect. In fact, the original grinding marks could still be detected. The importance of this discovery can scarcely be over-estimated; and if the manufacturer is doing a large proportion of roughing, it may be the means of doubling his output, assuming that he has already been using the best known steel.—*Franklin Inst. Jnl., Feb. 1903*, pp. 127–137.

The Micrographic Analysis of Steel.

In the introduction to this exhaustive paper, the author says he has tried to institute a systematic process which will permit of a classification of different reactions and the recognition under all circumstances of the different constituents of steel. The system described is admittedly imperfect, but, handled with prudence, it appears to the author to be an instrument of some utility in the study of metallurgical problems. The author then describes Preliminary Operations, and next commences a description of the special pro-

cesses which form the subject of the present essay. The chief heads under which the investigation is grouped are: General Method —The Primary Constituents of Steel—Micrographical Separation of the Constituents—Detailed Examination of a few Steels. In concluding, the author says that in the practical use of metallography, there should be, for every metal dealt with, a preliminary study. But this study once made it will be easy to tell with sufficient exactness the heat treatment a finished piece has received, to see if this treatment, which is of primary importance, has conformed to the fixed rules, and to remedy it if necessary. An excellent and very conclusive example of this has been given by M. Albert Sauveur, who has organised in the works of the Illinois Steel Co. a regular system of micrographical examination. The comparison of the results herein given with those in the important work recently published by M. Charpy, under the auspices of the Society of Encouragement, will probably furnish useful information. The author remarks that, for industrial works, the complete method that has been described is not generally necessary. Like the general rules of Analytical Chemistry, this method may be simplified as the occasion and experience may suggest. It is a method of investigation which is laborious when we are searching for the unknown. Ordinarily, the process will be much more rapid. **F. Osmond,** *Proc. Eng. Soc. Western Pennsylvania, Vol. XVIII., No. 9,* pp. 503-551.

Case Hardening Steel.

COMMENCING with the remark that, if properly understood, case hardening requires as much study and calls into play the reasoning faculty to fully as great an extent as the hardening of tool steel, the writer describes the methods to be followed when hardening various articles. He explains the best way of hardening small objects such as screws and nuts, giving hints for obtaining the best results and nice colours when such are wanted. The more common method of case hardening for work in large quantities consists in packing the articles in iron boxes with carbonaceous materials, placing in a furnace and subjecting to heat for a sufficient length of time to ensure the penetration of carbon to the desired depth. In order to insure uniform results, the writer uses a system of test-wire which affords a reliable means of showing when the box is heated through. The box is afterwards removed from the furnace and inverted over the chilling bath, provided the pieces of metal are of a size and shape that insure their becoming sufficiently chilled before reaching the bottom. If too large for this they should be wired before insertion in the bath. Directions are next given for dealing with slender or weak articles, and for obtaining extreme surface hardness without making the article brittle. Carbon is supposed to penetrate iron at the rate of $\frac{1}{8}$ in. in 24 hours. Therefore, in order to harden to the depth of $\frac{1}{32}$ in. it would be necessary to subject the article to heat for six hours after it was red-hot. A factor which should receive the greatest consideration is the selection of stock to obtain certain results. Articles which must resist shock, blows, or strains of any character should be made from open-hearth steel. When the article to be hardened must resist the action of blows it should be hardened so as to produce a fine, compact grain. The Harveyizing method, by which this end may be attained, is then described. When it is considered necessary to harden a portion of an article and leave the other parts soft, it may be accomplished by protecting the portion to be left soft with fire-clay mixed with water, adding a sufficient quantity of plasterer's hair to hold the mass together. The portion not so protected will become carbonised in the furnace, and will consequently harden when plunged in the bath. Sometimes the piece is subjected to the action of carbon on its entire surface, but the portion that is desired soft is covered when dipped in the bath. Another method for local case-hardening is to machine to size the portions that are desired hard before carbonising. After this process the other parts are machined, and are soft because the hard surface has been cut away. Still another method is is to nickel-plate the parts to be left soft. As carbon cannot penetrate nickel, the plated portion will be soft while the balance of the article will be carbonised and consequently will harden when dropped in the bath. —**E. R. Markham,** *Machinery, Feb. 1903,* pp. 317-319.

PRIME MOVERS.

Report of Committee on Standardising Engine Tests.

THE committee issuing this report was appointed, in 1898, by the American Society of Mechanical Engineers to codify and standardise the methods of making engine tests. It is evident that any work in this direction should be of such scope as not only to make rules for obtaining the necessary data and working out the results, but to determine a standard form of expressing the results and standard units in which they should be stated. The only common ground on which the various classes of heat-engines stand is that every one depends for its operation upon the use of

heat. In a steam-engine the weight of steam consumed is an unsatisfactory measure of performance, for the reason that the true thermal enonomy is affected by the initial pressure, by the quality of the steam, and by the disposition which is made of the rejected heat of the engine. Measurement on the heat-unit basis takes account of all these variables. It seems to be a foregone conclusion, therefore, that the standard of consumption for all classes of heat-engines should be referred to as heat units. The unit "horse-power" is accepted as satisfactorily expressing the power developed by an engine, and if it were possible in every case to determine the useful power delivered by an engine there would be good ground for making "brake horse-power" the unit. Such determinations are rarely feasible, and, on the other hand, it is not always possible to obtain the indicated horse-power, as, for example, in the case of steam turbines. It is therefore necessary to employ two units, viz. indicated and brake horse-power. The heat-unit standard does not interfere in any way with the common terms of expressing economy of engines, which should by no means be abandoned; neither should the standard forms recommended by the society for expressing the duty of pumping engines or the efficiency of locomotives. In the scheme now presented these additional or subsidiary forms of stating economy are suitably provided for. The heat-unit expression of economy does not in itself show whether the engine is working to its best advantage, and this point must be determined by an analysis of working conditions. The heat consumption of gas and oil engines is found by ascertaining the total heat of the combustion, and multiplying the result by the quantity of fuel consumed. The indicated horse-power for the proposed standard is that determined by the use of steam-engine indicators, and it should be confined to the power developed in the main cylinder or cylinders. In the code now presented, the standard published by the Inst.C.E. in 1898 is embodied, and one of the subsidiary forms is based upon the standard coal unit of 6,000 B.T.U. The code lays down forms of test as a standard for all engines, viz. (1) the heat-unit test; (2) supplementary tests for ascertaining efficiency; (3) the standardisation of methods and results with reference to the particular service of an engine; and (4) to systematise the work of testing gas, oil, and other internal combustion engines. Although engine-testing is a species of scientific investigation, the committee have kept in mind the fact that the one thing of highest importance is the practical result secured, not alone by the engine, but by the auxiliaries as well. In the code proposed the object has been to secure a plan of such breadth that whatever the special object of the engine test, whether it be a scientific investigation, a practical determination of everyday performance in the interest solely of the owner of the engine or a test in the interest of the engine builder, it will prove sufficient and suitable for all. The code of 1902 for steam-engine tests includes a series of twenty-six rules, and three tables. Tables I. and II. are arranged for the record of data and results of steam-engine tests, the first being a complete and the second an abridged form. Table III. is intended for similar records relating to feed-water tests of steam engines. The code of 1901 for gas and oil engines comprises eighteen rules and two tables, one in the complete form and the other in the short form recommended.—*Trans. Am. Soc. Mech. E., Vol. XXIV., No. 0957.*

The Dynamic Balance of the Connecting-Rod.

THE object of this paper is to investigate the effect of the inertia of the connecting-rod in communicating vibration to an engine, and to discuss the possibility of so balancing an engine as to remove such vibration entirely. It has frequently been laid down as a maxim, when dealing with an engine with a single crank and connecting-rod, that "reciprocating weights must be balanced by reciprocating weights, and revolving weights by revolving weights"; but the particles constituting the connecting-rod have neither a purely revolving nor a purely reciprocating motion; they describe oval paths, not differing greatly from ellipses, of different degrees of elongation, being nearly circular near the "big" or crank end of the rod, and narrow near the "small" or crosshead end. The particles do not even lie in the centre line of the rod, but different particles in the same cross section describe paths of different shapes. The author assumes a single-crank engine to be balanced on the usual supposition that any rod is equivalent to an imaginary rod, capable of transmitting thrust and tension, but entirely massless along the whole length, and having two heavy particles only in the centres of the crankpin and crosshead respectively, the engine having weights on extensions of the crank arms to balance the revolving weights and one heavy particle; and a weight equal to the reciprocating weights *plus* the other heavy particle, having its centre of gravity in the centre line of the engine, and actuated by levers or other mechanism, so that it is always moving at the same rate as the cross-

head, but in the opposite direction. It is clear that such an engine is statically balanced, that is, it will stay in any position in which it is put: it is also obvious that if fitted with a massless rod with two heavy particles in the ends, it would be dynamically balanced when the crank turns at uniform speed, if maintained at that speed by forces internal to the engine and its frame. But in an actual engine, with a rod whose mass is distributed along its length, the questions present themselves: (1) whether the dynamic balance is the same as if the rod were without mass and with two heavy points in its extremities; (2) if not, what is the defect from perfect balance of the material rod, at each point of the revolution; and (3) whether it is possible to modify the ordinary rod so as to remedy the defect. The author then enters upon a detailed discussion of these interesting points, but without arriving at the desired answers. In fact, he comes to the conclusion that it appears to be of little use to modify the ordinary connecting-rod, and hopeless to expect ever to perfectly balance an ordinary engine, even of the three-crank fan-engine type.—**C. A. Matthey,** *Inst. Eng. and Shipbldrs. Trans., Vol. XLVI., Part 4,* pp. 38-54.

Manchester Steam Users' Association.

In his last report the chief engineer gives the results of some experiments throwing light upon the question of "Steam Pipe Explosions." Under the head of "Grease in Boilers," he suggests that if the brittle scale were replaced by a more elastic material as, for instance, the dense grease which finds its way into a boiler, there would be less chance of injury. On the subject of "Boiler Efficiency" the writer says that those boilers are the least efficient in which the excess of air is largest, and that the amount of heating surface is of secondary importance. In other words, a higher efficiency and a better duty can be got out of a small boiler properly worked than out of a large boiler improperly worked. Detailed consideration is next given to "Heat Transmission"; double combustion is advocated; economisers and superheaters are discussed; and an exhaustive comparison of various types of steam boilers is presented. One point, the writer says, cannot be too strongly emphasised—viz. that perfect combustion is of far more importance, both as regards the efficiency of a boiler and the power to be got out of it, than is, within limits, either the amount of heating surface or its arrangment.—**C. E. Stromeyer,** *Memorandum to the Manchester Steam Users' Association Dec. 31, 1902.*

DYNAMOS, MOTORS, Etc.

The Heyland Induction Motor.

The arrangement devised by Mr. Heyland enables a power factor equal to unity to be obtained at all loads. This property, which is an advantage in itself, would seem to be further enhanced by the possibility of its enabling motors to be designed with larger air gaps than those of present motors. Ordinary well-designed induction motors give at full load a power factor equal to 0·9, which decreases slightly with the load, and is about 0·87 when the torque falls to about $\frac{3}{4}$ of its normal value. The principal merit of induction motors consists in their great simplicity of construction, which enables them to operate without requiring, so to speak, any attention or repairs. In order to slightly improve the power factor, and to raise it from 0·9 to 1·0, a motor even more complicated than a direct-current motor has been devised, which, owing to the losses in the commutator shunting resistances, has an efficiency materially lower than that of the present induction motors; and, besides, it is by no means certain that in practice the new machines will remain constantly regulated for a power factor equal to unity. The writer pronounces no opinion as to the commercial success of the invention, but he has a firm belief that new improvements, and perhaps new inventions, will eventually make the induction motor the ideal machine.—**B. De La Tour,** *Elec. Wld., Vol. XLI., No. 12, March 21, 1903,* pp. 479, 480.

Automatic Regulation of Voltage in Central Stations.

A new type of quick-acting automatic voltage regulator, recently developed by Mr. A. A. Tyrell, is applicable to either continuous or alternating current circuits, and may be used for keeping the voltage of the generators constant, or for automatically regulating feeder pressures. A novel feature of the regulator is that the control is effected by opening and closing a short circuit on the field rheostat, thus cutting in and out resistance in the field circuit of the generator, the voltage being varied by the length of time the resistance is included in circuit and out of circuit. This operation is made at a high rate of speed, varying from 50 to 800 times a minute, and the movement of the contacts which switch the resistance in and out is accomplished by a relay, the motion of the contacts being about $\frac{1}{16}$th of an inch. The voltage of an alternating-current generator is controlled by varying the resistance in the field of the exciter, and it is claimed for the apparatus that when once adjusted it will maintain constant potential.

Without any further attention, and quite irrespective of the character of the load and speed, the alternating-current and direct-current control magnets together operate a pair of floating contacts, which in turn operate the relay magnet; and the latter opens or closes the shunt circuit across the exciter field rheostat. The apparatus applies so much energy in changing the voltage that it overcomes at once any reluctance of the field. For that reason the exciter has to be one with a wide range of voltage, say, 125 volts down to 40 volts, to get a 110-volt working result. To reduce the voltage of the alternator slightly, the apparatus is first varied considerably, and then brought back to the position required, just as with a hand regulated rheostat for quick regulation the arm of the rheostat is momentarily thrown clear round, and then brought back to the point at which it is to remain. The supply of current to customers at constant pressure is a very important matter, because an increase of only 1 per cent. has a marked effect, and may reduce the life of a lamp by some 18 per cent., whilst only increasing its candle-power by 6 per cent. Another point in connection with this matter is that high-efficiency lamps, taking 3·1 watts per candle-power, can only be used when the voltage is maintained constant. Where there is pressure variation, lamps taking 3·6 watts or more have to be used, and this means that for any given station the lamp connection may be reduced as much as 14 per cent. If, therefore, by the addition of an automatic regulator or other means, any improvement is made in the supply voltage, the additional expense and complication of such apparatus may be justifiable.—**E. Kilburn Scott,** *Elec. Rev., Vol. LII., No. 1,320, March 13, 1903*, p. 466.

BATTERIES, ACCUMULATORS, AND ELECTRO-CHEMISTRY.

High Temperature Electro-Chemistry.

THE difficulties in the way of the commercial application of the electric furnace having been overcome in the case of calcium carbide, efforts were made to produce some of the rarer metals on a large scale in a similar type of furnace. The valuable qualities of these metals in the manufacture of steel ensured a ready market for them. Among these, ferro-chromium takes an important place. At the present time one factory alone in America is using 450 tons of 70-per-cent. ferro-chromium for armour plate work, and large quantities are used in this country for various qualities of steel. Tungsten and ferro-tungsten, which have been used for a considerable time for manufacturing self-hardening and high-speed tool steels, can also be satisfactorily manufactured in the electric furnace; and the last-mentioned product has the advantage that it is in a compact fused form, and is thus less liable to oxidation in the process of adding to the steel. Ferro-silicon is another important alloy, the manufacture of which has been taken up in several factories where calcium carbide can no longer be produced with sufficient economy. The grade varies considerably, from 15 to 85 per cent. The application of ferro-silicon is in the casting of iron and steel, where it plays the important part of a deoxidiser, thus obviating blow-holes, and at the same time rendering the metal more fluid. Copper-silicon has been prepared for a long time in the Cowles furnace, and has found considerable application as a deoxidiser, as well as for increasing the tensile strength of copper and brass castings. Among the rarer metals which have not hitherto received any wide technical application, ferro-titanium and ferro-vanadium may be mentioned. These alloys have recently been shown to possess distinct value in the steel industry, and the difficulties connected with their production have been largely overcome. Carborundum, in addition to its use as an abrasive, is of value in the steel industry, replacing ferro-silicum to a considerable extent. The author describes and illustrates different types of the electric furnace, and describes its application in connection with the production of various substances and metals, such as artificial graphite, aluminium sodium, caustic soda, zinc, manganese, phosphorus, nitric acid, fused alumina, baryta, etc. He also adds some notes upon the application of the electric furnace to the melting of steel and to the glass industry. The process described in each case is selected as being one worked on a large commercial scale.—**R. S. Hutton and J. E. Petavel,** *Jnl. Inst. Elec. Eng. Vol. XXXII., Pt. I., No. 159, Feb. 1903*, pp. 222—247.

Recuperating Dry Batteries.

ORDINARY dry batteries, after being "spent" and abandoned, can practically, and with little or no trouble or expense, be repeatedly renewed in the manner thus described by the writer:—"One cell was connected in series with a single 16-candle-power 110-volt lamp, using the latter for illuminating, as its brilliancy was not perceptibly decreased by the slight voltage drop. After about one hour the cell was disconnected, and on being tested proved to be as strong as when new. At another time groups of

cells joined in multiple were connected in series with a ventilating motor, and still another lot were coupled all in series in connection with an electrolytic bath; every cell was recuperated and seemed in every respect as good as new, life and efficiency included. In the two years' time most of these cells have in this manner been recharged several times, and only three abandoned, the latter from want of attention."—**W. A. Sherlock,** *Elec. Wld, Vol. XLI., No. 9, Feb. 28, 1903*, p. 367.

Electro-Chemical Industries.

THE process most commonly employed for the production of hydrogen is that of M. Renard, in whose apparatus iron electrodes and a 1 to 6 solution of caustic soda are employed, the potential difference being about 3 volts. This apparatus is capable of carrying a current of 400 amps., and of furnishing 80 litres of oxygen and 160 litres of hydrogen an hour, the energy absorbed being about 1·6 h.p. per hour. The preparation of hydrogen in this manner has not been commercially developed to any great extent, and the gas thus produced is chiefly employed for the inflation of military balloons. The attempt has been made to use electricity for the concentration of sulphuric acid. In sending an electric current through the acid to be concentrated, heating is directly attained; but, of course, the difference of potential should not be sufficient to produce electrolysis. But the use of electrical energy in this manner is more costly than the most economical method of heating by fuel, and the electrical process cannot be practically realised until considerable economies have been effected in the production of energy. The most important industry in this branch of electro-chemistry is the electrolysis of chloride of sodium. This operation is employed (1) for the manufacture of caustic soda and the production of chlorine gas; (2) for the preparation of hypochlorites or bleaching liquids; (3) for the manufacture of chlorates. The writer briefly describes the apparatus used in these departments of industry both on the Continent and in Great Britain, and refers to the numerous uses of electricity and of electrolysis in chemistry, particularly mentioning the rectification of alcohols, their artificial "ageing," the preparation of colouring materials, and electric tanning. In conclusion, he reviews the principal electro-metallurgical industries, and points out the favourable conditions existing in France for the adoption of electro-chemical processes. — **M. Gall,** *L'Electricien, Vol. XXV., No. 631, Jan. 31, 1903*, pp. 74-77.

WATER.

Biological Purification of Water.

THE purification of trade and other effluents on a rational and satisfactory basis is one of those problems which demand the most serious attention of scientific men and public authorities. After demonstrating the function and the action of microbes in the successive decomposition of organic matters, the author describes the anaërobic bacterial process, with double aërobic contact. This process has been adopted at numerous places in England, and is now being made the subject of investigation and experiment by the technical department of l'Assainissement de Paris. The author comes to the conclusion that the system possesses the great advantage of being applicable alike to large cities and small villages.—**H. de Montricher,** *Bulletin de la Soc. Scientifique Industrielle de Marseille, 1901*, pp. 153-179.

Irrigation Weir on the Bhadar River, India.

THIS paper describes the construction of the weir intended to complete the reclamation and irrigation of 80 sq. mls. of land at the delta of the Bhadar River, discharging into the Indian Ocean. The present shore line appears to have risen, enclosing shallow lakes which have silted up by the deposit of mud brought down by flood waters. A dam, 1800 ft. long, built in 1895, has excluded the sea from the greater part of the Rann, and the weir now completed permanently retains the silt and prevents the formation of dust, in which form considerable quantities of silt have been lost every year. The weir is about 600 ft. long, and is of very open character, being in fact a bridge having a sill which can be temporarily raised by wooden shutters to hold up the river water. There are twenty openings, each 24 ft. wide, closed with shutters 8 ft. high, and a navigation lock is provided, 20 ft. wide by 11 ft. deep over the sill. The whole of the lock abutment and the pier foundations are built on square masonry wells sunk to the rock. Full description is given of the method adopted in sinking the wells, of sluice details, and of the working of the weir.—**J. J. B. Benson,** *Proc. Inst. C.E., Session 1902-3, No. 11.* Paper read March 10, 1903.

The Panama Canal.

ON March 5, 1902, a paper on one of the most important details of the Panama Canal was presented by the writer. The present paper covers a larger scope, and takes up the principal features of that undertaking. Much has been said of the great value of a tide-level canal and its unlimited capacity. This

unlimited capacity is more apparent than real. A tide-level canal will require a tide lock at the Pacific end, and, although both gates can be left open at mean tide, so that the length of lock is not a limiting factor, its breadth and depth are. The difficulty of controlling floods is greater in the tide-level canal than in the canal with locks, and the advantage of a broad inland lake is lost. Still, the writer believes that the tide-level canal would be the better canal when done, but that the difficulties which would attend its construction, the greater cost, and especially the longer time involved, preclude its selection. In this paper both plans of canal are described and comparative estimates given in some detail. The estimates are based on the report of the Isthmian Canal Commission, modified to suit changes in plans. The cost of a canal on the tide-level plan would be approximately 238,000,000 dols., and the cost of a lock canal, as described in this paper, the summit level varying from 85 to 90 ft., with three locks on each side, is estimated at 125,760,000 dols. The paper is illustrated with a plan, two profiles, diagrams and tables.—**G. S. Morison,** *Proc. Am. Soc. C. E., Vol. XXIX., No. 1, Jan. 1903,* pp. 15–44.

MECHANICAL.

The Nature of Worm-Thread Contact.

THE writer says that he formerly supposed the contact of worm-thread and gear contact to be along a continuous line more or less curved, somewhat like the contact lines between the teeth of a rack and gear, which are continuous though not curved. In his "Treatise on Gears" Mr. Grant says—"The nature of the contact between the worm and the concaved worm-gear has not yet been definitely determined, but there is no reason to suppose that it is different from that between plain spiral teeth—a point of contact on the normal spiral—but it is probably continuous." Also, "The action between spiral teeth is not upon the axial section, and it is not that of a rack and gear; but when there is any action at all it is upon the normal spiral section." The writer, holding a different opinion, felt he must base it upon original investigation with models so exact that the observed results would be believed, even though they conflicted with mathematical theories. A worm and worm-wheel were consequently made with the greatest possible accuracy, finished perfectly smooth, and carefully fitted up so that their action could be observed. Upon covering one member with colouring material, and rotating the two members in mesh, the rubbing off of the colour determined that the contact between a tooth and a thread is along a line. Two other proofs were obtained, and the writer says he was forced to conclude, from direct investigation, not depending upon any previously known principle of gearing, that the contact between a worm thread and a tooth of a worm-wheel is along a line.—**Oscar J. Beale,** *Amer. Machst., Jan. 31, 1903,* pp. 92, 93.

MISCELLANEOUS.

Electric Safety Fuses.

THIS paper discusses the evolution, principles, operation and application of safety fuses, and gives special attention to the enclosed fuse, of which one type, the "Noark," has been devised by the author. In the earlier forms of enclosed fuse an air-space was always left, but in modern fuses of the "Noark" type the enclosed space surrounding the fuse is completely filled with a powder of some insulating material. This powder should have even and unvarying thermal characteristics, and when placed in the fuse tube it should have innumerable interstices between its particles. Thus a coarse-grained powder is best. In the author's fuses a fluxing material is mixed with the filling, and at melting temperatures this acts on the oxide film surrounding the conductor. Enclosed fuses should be tested under all conditions of service, both overload and short-circuit, for one which acts satisfactorily on short-circuit may operate disastrously under the much smaller disruptive strain of a small overload. The break should be absolute to ensure safe operation. As there is no exterior manifestation of the interior condition of an enclosed fuse, artificial means have to be supplied to enable an observer to know whether rupture has taken place. This is done by short-circuiting the ends of the fuse by a wire of high resistance, part of which is brought outside the case by holes in the sides. This portion is covered by a label, underneath which, and in contact with the indicator wire, is a spot of material affected by the heating and destruction of the wire, causing discolouration of the label. The indicating wire normally carries no current, but when the fuse is melted, the shunt comes into play and the effect is seen on the label. For motor-protection they are specially suitable, as they are really time-interval fuses. **J. Sachs,** *Jnl. Franklin Inst., Vol. CLV., Jan. 1903,* pp. 1-35.—*H.*

The Engineer's Book-shelf

❀ ❀ ❀

Dynamics of Rotation.— An elementary Introduction to Rigid Dynamics. By A. M. Worthington, C.B., M.A., F.R.S., Headmaster and Professor of Physics at the Royal Naval Engineering College, Devonport. Fourth Edition, 1902. 164 pp., small 8vo., 4*s.* 6*d.* London : Longman, Green & Co.

The subject which the author deals with in this little volume is one of peculiar fascination when the student once begins to lose fear of the seeming difficulties with which it is surrounded. Probably the belief in the difficulty of the subject is largely due to the fact that it is usually treated from the purely mathematical point of view rather than from the physical, and pages of mathematical symbols and equations frighten off the reader. But it would be a great pity if by an erroneous method of treatment authors should write only for the few instead of for the many, and for this reason a book like that now before us is most welcome. The mathematical aspect of the subject, real and attractive as it is, is left aside, and the student is made to study physical results and from these derive his first ideas of dynamical phenomena. The text is simple, and any student who has a good grasp of the ordinary dynamical principles will find it an easy matter to follow out the author's treatment of rotational dynamics. In many cases there are exact analogies in the two systems, and these are always emphasised. As the present reprint is a fourth edition of Mr. Worthington's work, it is evident that he has met with success in the object he had in view. There is sometimes a slight want of connection apparent between consecutive portions of the book, but this is probably unavoidable in dealing in so concise a form with a large subject. One criticism we should like to make. The author, as a teacher, is aware of the confusion between *mass* and *weight* so prevalent in the minds of students, and sometimes, we regret to say, among teachers themselves and even text-book writers, and he has endeavoured to avoid this by adopting the convention of using the word "pound" when a force is meant and "lb." when a mass is meant. Now this, we believe, to be wrong, and likely to confuse rather than to prevent confusion. In the first place, "pound" is *never* a force and it is wrong to recognise such use of the term ; it is a mass, and if we wish to denote a force we must speak of a "pound weight," or "weight of a pound." "Lb." is simply a symbol for "pound," and word and symbol can only mean the same thing. Only a few lines above the place (p. 9) in which the author lays down this convention, he says "the unit of force is the poundal." This is correct, and so also is the expression "the pound pull as unit of force" in the following paragraph, but the expression immediately after this, "each force is one pound," is wrong. We have thought it proper to deal with this point as even the author, in spite of his convention, is not free from confusion on the subject, for on p. 21 he speaks of "a thin cylinder or hoop, of one foot radius *and weighing one lb.*" Here the symbol "lb." which is to denote *mass* is used to denote *weight.* What should have been written is "and of mass one lb." The author says his convention has been adopted in America ; if so, we are sorry this should be the case.

Differential Calculus for Beginners.—By Alfred Lodge, M.A., Professor of Pure Mathematics at the Royal Indian Engineering College, Cooper's Hill. With an Introduction by Sir Oliver J. Lodge, D.Sc., F.R.S., LL.D. 1902. 8vo, 278 pp (Cambridge Mathematical Series. London : Geo. Bell & Sons. Cambridge : Deighton Bell & Co.)

This little book appears to us to give a very excellent introduction to the differential calculus. The author has from the outset kept clearly before his readers the practical application of the calculus, so that students are not likely to fall into the error—somewhat common—of considering differential coefficients as merely abstract mathematical symbols, and the calculus itself as a species of mathematical jugglery, clever and in some respects attractive, but of little real use to the practical man. The truth is, in fact, quite otherwise ; and Professor Lodge has gone far to assist his readers to a knowledge

of the true position of the calculus. In this respect he has been assisted by his brother, Sir Oliver Lodge, one of the most practical of men in the physical world, but also deeply versed in theory, who has provided an introduction for this book, in which the practical applications of the calculus are very concisely and clearly sketched. Mr. Lodge has wisely introduced his readers at a very early stage in the book to graphic representations of functions, showing the meaning of the differential coefficient by reference to the curves, and by this means dispelling at once much of the mystery which is apt to surround the use of differentials when the student is introduced to them from the pure mathematical standpoint. The book contains, *inter alia*, chapters on Curvature of Plane Curves, Partial Fractions, Taylor's and Maclaurin's Theorems, Partial Differentiation, and Curve Tracing; so that the ground covered is fairly extensive, and the reader should be able to acquire here a sound knowledge of the principles of the calculus. It is usual to find Maclaurin's theorem treated before Taylor's in books on the calculus, but Mr. Lodge has reversed the process, and rightly so, for the former is but a particular case of the more general theorem of Taylor. We cordially recommend this little book.

The Analysis of Steel-Works Materials. By Harry Brearley and Fred Ibbotson. (London: Longmans, Green & Co., 1902.) 14*s*.

In dealing with a subject of great importance and most comprehensive nature, the authors have been distinctly successful. The processes described by them are selected from those in actual use in laboratories attached to iron and steel works, and throughout the treatise the object has been to consider the subject in a practical, rather than in an academic manner. Consequently there are few, if any, of those omissions which too frequently characterise text-books written by mere theorists, and the student will find in this manual a valuable guide. It contains thirteen parts, devoted to the analysis of steel, pig-iron, steel-making alloys, ores, refractory materials, slags, fuel, engineering alloys, and to rapid analysis at the furnace, boiler feed-water, boiler scale and micrographic analysis. A series of miscellaneous notes concludes the treatise proper, and then follows an appendix of 140 pages, containing a most complete bibliography, giving 1,858 references to articles and papers relating to the examination of steel-works materials. It would be impossible to speak too highly of this compilation, which has been brought up to the end of 1901, and must have involved an immense amount of labour.

The Art of Illumination.—By Louis Bell, Ph. D. (New York: McGraw Publishing Co.) 1902.

In this volume the author makes a study of the scientific application of distributing illuminants, only treating of illuminants themselves to a sufficient extent that their intelligent use may be demonstrated. The science of light production is necessarily progressive, but the art of employing available materials and apparatus is governed by clearly-defined and unchangeable laws. To make the application of these clear, is the aim of the author. The first three chapters are occupied with a discussion of the principles forming the basis of artificial illumination; the chapters immediately following being devoted to the properties of practical illuminants and their bearing upon the development of modern lighting. Much practical information is contained in the chapters upon electric incandescent lamps and arc lamps, and a valuable collection of data is given in the chapter dealing with shades and reflectors. The lighting of houses, public buildings, and streets is taken up in successive chapters and examples are worked out in detail. Towards the end of the work, the essential principles of decorative illumination and the future of illumination in general are thoughtfully considered. The volume closes with a description of modern photometric methods. As an intelligent exposition of a most interesting and important branch of practical art, this treatise deserves a wide circulation among engineers and others who have to deal with lighting problems, and also among those who are concerned in the manufacture and sale of materials and apparatus for illumination.

Submarine Warfare. By Herbert C. Fyfe. (London: Grant Richards, 1902.) 7*s*. 6*d*.

As a general axiom, it may be stated that the popular treatment of a technical subject is rarely acceptable to the technical man. We are pleased to refer to Mr. Fyfe's most interesting book as an exception. He has placed on record an admirable review of what has been accomplished in the development of submarine war vessels, thus making it possible for the people who own the British Navy to obtain an adequate idea of the latest mode of attack which may some day be directed against it.